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CONSUMPTION AND LABOUR SUPPLY: RELAXING THE INTERTEMPORAL AND INTRATEMPORAL SEPARABILITY ASSUMPTIONS

Soteria Hajispyrou

University College London
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I hereby declare that the work submitted for my thesis is my own.

Soteria Hajispyrou

Signature

ABSTRACT*

In the first chapter of the thesis, the consumption insurance hypothesis is tested using the Euler equation framework and applying it on a utility function that is nonseparable in consumption and leisure. The aim is to investigate whether the restrictive way in which leisure enters the equation for the growth of consumption affects the acceptance or rejection of the theory. In general, research on risk sharing in consumption investigates a number of explicit and implicit insurance mechanisms under which the consumption growth rate between households would differ because of changes in the earnings capacity and income, whether anticipated or not. In the case of complete markets and identical tastes and isoelastic preferences, it is implied that there is no idiosyncratic variation in the growth of individual consumption. However, the results are not altogether conclusive. In the first chapter, a test of the consumption insurance hypothesis is conducted, controlling for nonseparability between male leisure and household consumption in the utility function. Because the proper modelling of labour supply is beyond the scope of this study, leisure is treated as a conditional variable in the equation for consumption. An Euler equation approach is adopted where the results from the Euler equation of consumption are used to construct the growth of the log of marginal utility to be finally be used to test the consumption insurance hypothesis. The results indicate towards a rejection of the consumption insurance hypothesis for the quarterly series.

Intratemporal nonseparability between consumption and leisure is one issue, but not the only one. Other important issues that should be taken into account are the intratemporal nonseparability between durable and nondurable consumption and the intertemporal nonseparability implied by durability and habits. The second chapter investigates the effect of durability and habit formation on consumption in a dynamic almost ideal demand system, and shows that time effects are still significant when household heterogeneity is taken into account. The third chapter models commodity demand and leisure jointly, taking an unconditional approach, separating male and female leisure in a dynamic context. The results indicate that nonseparability between consumption and leisure cannot be rejected, and that durability and habit effects are once again significant not only for commodity demands but also for male leisure.

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CHAPTER 1

CONSUMPTION, INSURANCE AND LABOUR SUPPLY

ABSTRACT. This paper uses a two-step estimation procedure for optimal life-cycle consumption growth in the presence of nonseparability between consumption and labour supply choices. Synthetic cohort techniques and the Consumer Expenditure Survey data are employed to construct average quarterly age-profiles of consumption, labour supply and income of married couples over their life-cycle. The Cobb-Douglas isoelastic utility function is used where the utility function coefficients that determine the intertemporal elasticity of substitution for leisure are estimated using an Euler equation. The results indicate towards a rejection of the consumption insurance hypothesis for the quarterly cohort series used.

1. INTRODUCTION

This paper uses a two-step estimation method of the life-cycle model of consumption in order to investigate whether consumer data support the consumption insurance model. The aim is to utilize the log-linearized Euler equation when considering nonseparability between consumption and leisure.

The assumption that preferences are separable in consumption and leisure is generally regarded as restrictive and possibly unrealistic. A household with working adults will probably have considerably different spending patterns than households with non-working adults. Consumption on several commodities will be increased, like transport for travel to and from work, clothing and footwear for work, meals outside of the home. Furthermore, in a household where both partners work, certain services that would otherwise have been provided by the non-working partner, have to bought on the market, such as child care. However, there have been few attempts in the empirical literature to allow for more general preferences. Some examples of important contributions in the literature modelling nonseparability, albeit in very different ways, are Browning et al (1985), Holtz et al. (1988), Altug and Miller (1990), Blundell et al (1993), Attanasio and Weber (1995), Attanasio and Davies (1996), Blundell and Walker (1982), Browning and Meghir (1991) and Meghir and Weber (1996).

Preceding the life cycle-permanent income model of consumption, it was Keynes' theory of consumption that dominated the field. According to Keynes, in his general theory presented in 1936, households increase their consumption when their incomes increase, but not as much. It follows that in periods of economic growth, the proportion of savings to national income increases. The theory gained acceptance among Keynes' contemporaries, but was later contradicted to empirical facts, as Kuznets (1951) first pointed out based on U.S. data. It was Friedman (1957) when he formed his permanent income hypothesis that provided a rational explanation of the Keynes-Kuznets contradiction within a framework of a general, well defined, theory of consumer demand over time.

The central idea of the permanent income hypothesis is that people base consumption on what they consider their "normal", or permanent, as

Friedman called it, income. In doing this, they attempt to maintain a fairly constant standard of living even though their incomes may vary considerably over the time periods. As a result, increases or decreases in income that people see as temporary have little effect on their consumption spending. Friedman argued that Keynes' proposition was incorrect because it was derived from empirical observations of cross- section data referring to total, not to permanent income, which also contains the transitory part of a person's income.

Three years earlier than Milton Friedman, Modigliani and Brumberg (1954) published their theory of the life cycle hypothesis. Like Friedman, Modigliani and Brumberg assumed that households strive to maximize their utility of future consumption. The important difference between their works lies in the time length of the planning period. For Friedman this is infinite, implying that individuals save not only for themselves but also for their descendants, as opposed to Modigliani and Brumberg who consider a finite time span where individuals save only for themselves. In both instances, consumption decisions are treated as part of an intertemporal allocation problem. As with the allocation of total expenditure among commodity demands in demand analysis, intertemporal prices and the total amount of resources available to an individual are parts of the decision making process. Therefore, the life cycle-permanent income model is purely microeconomic.

As such, it has been proved particularly useful in investigating the effects of different pension systems. Most of the work indicated that the introduction of a general pension system leads to a decline in private saving, a conclusion in full agreement with the Modigliani-Brumberg hypothesis.

Much of the recent empirical literature on the consumption insurance hypothesis adopts the Euler equation approach, following the famous paper by Hall (1978) where he derived the random walk property of consumption. In general, research on risk sharing in consumption investigates a number of explicit and implicit insurance mechanisms under which the consumption growth rate between households would differ because of changes in the earnings capacity and income, whether anticipated or not. In the case of complete markets and identical tastes and isoelastic preferences, it is implied that there is no idiosyncratic variation in the growth of individual consumption. The same argument can be supported by the presence of other mechanisms or institutions, such as social security programs, private insurance and charities, or even through the effects of the extended family or other informal mechanisms. The empirical results, however, are not altogether conclusive.

This paper proposes a test of the consumption insurance hypothesis controlling for nonseparability between male leisure and household consumption. Because the proper modelling of labour supply is beyond the scope of this paper, leisure is treated as a conditional variable in the equation for consumption. The results indicate towards a rejection of the consumption insurance hypothesis. Section 2 reports the empirical evidence of previous work on the consumption insurance hypothesis, and then Section 3 describes the modelling procedure in the paper, where Section 3.1 describes the intertemporal optimization model and Section 3.2 the Euler equation. Section 4 starts with a description of the Consumption Expenditure Survey data used, explains the age cohorts created and provides descriptive statistics that show, among others, that consumption profiles closely follows the income profile. Sections 4.2 and 4.3 report the estimation results of the Euler equation and the lifecycle model of consumption which provide reasonable parameter estimates for the intertemporal elasticity of substitution for male leisure and also show that nonseparability actually shows evidence in favour of the consumption insurance hypothesis. Finally, Section 5 concludes.

2. PREVIOUS LITERATURE RESULTS

Mace (1991) tests the existence of complete markets in the US and whether household consumption changes are insensitive to household income changes conditioning on the aggregate consumption change. Using the Consumer Expenditure Survey, Mace runs simple regressions of the change in household consumption against the change in aggregate consumption, change in household income and other variables, such as the change in employment status. She finds that change in household income is an insignificant variable and so fails to reject the prediction of the complete markets model. She also runs regressions using the rate of growth of consumption and for only one specification which assumes power utility, idiosyncratic income growth matters. For the rest of the specifications, however, her results are consistent with full consumption insurance.

Attanasio and Weber (1993), replicate Mace's regressions using the CEX data, with the difference that they employ cohort techniques. Cohort averaging aims to reduce measurement error in the variance of income growth which would bias the regression coefficient of income changes towards zero. Indeed, they find evidence against the existence of complete markets in the US. For their regressions they use quarterly cohort average series and condition on the aggregate quarterly growth rate of consumption. The growth rate of quarterly cohort income turns out to be very significant in explaining the corresponding growth rate of consumption.

The results of Cochrane (1991) using PSID data agree with those by Attanasio and Weber, in the sense that consumption changes are found to be strongly related to income changes. However, he considers only data on the growth rate of individual food consumption which on its own is a very serious limitation. Considering only food consumption can only be justified if it can be shown that utility is separable between food consumption and consumption on other goods. Indeed, this is an assumption that has been rejected by all studies on demand systems. Attanasio and Weber (1996) stress this point and provide evidence that nonseparability between food and other nondurable consumption is an important problem. In the same paper, they assume nonseparability between consumption and leisure and use the CEX data to test the consumption insurance hypotheses using the log-linearized Euler equation. The growth of consumption is regressed on the growth of labour income and other variables like labour supply variables and household demographics. They show that when omitting labour supply variables from the specifications, the coefficient on labour income growth is very significant. Excess sensitivity, however, disappears when labour supply variables are included in the regression.

Browning et al (1985) use the British Family Expenditure Survey data for the period 1970-77, to derive panel like information on male labour supply and consumption for age cohorts. They find that consumption and income profiles track each other over the life cycle for manual and non-manual workers. They consider nonseparability by estimating equations where they regress the level and the first difference of consumption onto the real wage, prices and household demographics (number of children in age groups). They find that in the specification of the levels the coefficient on real wage is highly significant with a positive sign, indicating that male leisure and goods are substitutes.

Attanasio and Davis (1996) test the consumption insurance hypothesis using relative wage movements across birth cohorts and education groups. In their paper, they use the Consumer Expenditure Survey (CEX) and the Current Population Survey (CPS). In the CEX they form synthetic panel data consisting of 5-year birth cohorts crossed with education groups and they follow the same procedure with the CPS data. Their consumption measure consists of household nondurable consumption. They calculate hourly earnings from the CPS which they convert to real wages using the gross domestic product deflator for personal consumption expenditures. They estimate a number of specifications where they regress the log of annual average cohort consumption onto man's wage, woman's wage and woman's leisure as well as family size and composition variables. They also consider difference specifications and also estimate specifications where the sample is restricted to married couples. As they report, their results constitute a "spectacular failure" of the consumption insurance hypothesis since male wage variables turn out to be quite significant in the majority of the specifications considered. They test whether nonseparability between consumption and male labour supply affects the results by running the same regressions as above, but using a different dependent variable. The latter, in the presence of nonseparability, is the marginal utility of consumption that emerges from considering the following nonseparable preferences:

$$U(C_t^j, \bar{L} - H_t^j, \delta_t^j) = b_t^j (C_t^j)^{1+\gamma^j} (\bar{L} - H_t^j)^{1+\phi^j},$$

where $\bar{L}$ denotes the time endowment in hours, and H_t^j denotes hours worked. The implied marginal utility of consumption depends on the values of γ and φ. Attanasio and Davis consider a number of values for the two parameters so as to satisfy a range of values of the intertemporal substitution elasticity. Their results indicate that not even nonseparability can explain the rejection of the consumption insurance hypothesis.

This paper concentrates on the consumption-leisure nonseparability issue. The main issue to be tested is whether when we allow for nonseparability with labour supply (or leisure) we find more evidence of insurance across cohorts and education groups. The work builds on the work by Attanasio and Weber (1995) and Attanasio and Davis (1996) by taking a more general approach of the consumption-leisure nonseparability.

3. MODEL

3.1 The intertemporal optimization model

The consumption insurance hypothesis states that in the case where markets are complete, or where there are mechanisms for sharing consumption risks, then an individual's consumption does not respond to idiosyncratic income or wealth shocks. In this case, individual consumption growth completely tracks growth in group average consumption. In other words, the growth in the marginal utility of consumption across individuals and groups of individuals is equalized. This condition is derived from the optimization problem of the central planner who, given a fixed set of Pareto weights, allocates resources under uncertainty across individuals and over time. Formally, the optimization problem of the central planner for N individuals and T periods of time, given a nonseparable utility function in consumption and leisure, is represented by the following:

$$\max_{C} \quad \sum_{j=1}^{N} \sum_{t=1}^{\infty} \sum_{s^t} \pi(s^t)(\rho^j)^t \lambda^j U(C^j(s^t), L^j(s^t), \delta^j(s^t)) \qquad (1)$$

$$\text{subject to} \quad C^A(s^t) \leq e^A(s^t) \qquad (2)$$

where $C^j(s^t)$ and $L^j(s^t)$ denote consumption and leisure respectively of household j at time t in state s^t, $\pi(s^t)$ is the probability that state s^t occurs, ρ^j is the rate of time preference, $\delta(s^t)$ are arbitrary preference shocks and λ^j is household j's Pareto weight. The feasibility constraint (2) states that aggregate consumption must be less than the aggregate endowment, at each date and in each state.

The first-order condition of the optimization problem is, after dropping the notation denoting the state with a simple subscript t:

$$(\rho^j)^t \lambda^j U_{C_t}(C_t^j, L_t^j, \delta_t^j) = \mu_t \qquad (3)$$

where μ_t denotes the Lagrange multiplier associated with the feasibility constraint (2) and the time-invariant Pareto weights λ^j are equivalent to individual fixed effects. The use of cohort data effectively requires the partitioning the households into groups, indexed by *i*. After partitioning, taking logs in (3) and averaging over the sample of group *i* household at time *t*, we obtain

$$\hat{V}_{it} \equiv \frac{\sum_{j\in i(t)} \log[U_C(C_t^j, L_t^J, \delta_t^J)]}{\# i(t)} \tag{4}$$

$$= \log \mu_t - t\frac{\sum_{j\in i(t)} \log \rho^j}{\# i(t)} - \frac{\sum_{j\in i(t)} \log \lambda^j}{\# i(t)}$$

where $\# i(t)$ denotes the number of households belonging to group *i* at time *t*. A specification than can be used to test the perfect insurance hypothesis in "level" form is

$$\log U_{C_t} = cons + d_t + g_i + a \log x_t + e_t \tag{5}$$

and in first differences it is expressed as,

$$\Delta \log U_{C_t} = cons + d_t + a \Delta \log x_t + e_t \tag{6}$$

where d_t captures preference variation. Consumption insurance implies that $a = 0$. Variable x_t (e.g. labour income) should represent variables uncorrelated to preference variation parameters and measurement error e_t. Attanasio and Davis (1996) estimate a similar equation to (6), using synthetic panel construction with the US Consumption Expenditure Survey data. The test of the consumption insurance hypothesis comes down to testing the significance of parameter a. If $a>0$ then the hypothesis is rejected by the data.

I assume that utility is isolestic and not separable between within-period consumption and male leisure. When nonseparability between consumption and leisure is ignored it is essentially implied that one fails to control for leisure, or labour supply, in specification (6) and this can lead to a false rejection of the hypothesis by obtaining significant estimates of a. The reason lies in the fact that changes in income are correlated with hours of work and expenditures on goods related to labour supply.

Given nonseparable preferences between consumption and male labour supply, $\Delta \log U_{C_t}$ contains both consumption and leisure, the particular form of which depends on the form of nonseparable preferences that are set. The test of nonseparability between male leisure and consumption relies on computing the marginal utility function. The x_t chosen to test the hypothesis in this paper is male wages. What this method achieves is that it gives a formulation of equation (6) that does not include consumption, male leisure and male wages in the same formulation. That would render the testing of the consumption insurance hypothesis impossible in this context.[2]

I propose that an Euler equation could be estimated in order to construct $\Delta \log U_{C_t}$ to be used in equation (6) to, finally, test the consumption insurance hypothesis.

3.2 Euler equation

The problem described in Section 3.1 aims to test one of the main implications of the life cycle model, which is the fact that households attempt to smooth consumption over time. To that end, it tries to investigate to what extent implicit or explicit contracts, family networks (e.g. extended families), social safety nets etc. can approximate the intertemporal allocation that would prevail under complete contingent markets of the kind described in an Arrow-Debreu equilibrium.

The idea of consumption smoothing is the fundamental idea that underlies the Euler equation approach to intertemporal allocation. Namely, the Euler equation for consumption states that the marginal utility of wealth is kept constant over time. This can be derived by solving the problem faced by the individual who chooses consumption and leisure for each period of his/her life in order to maximize expected utility subject to an intertemporal budget

[2] As Attanasio and Davis (1996) point out, including in an equation consumption, male leisure and male wages is observationally equivalent to the intratemporal first-order condition governing the consumption-leisure choice.

constraint. It is assumed that utility is additively separable over time, but consumption is not separable from leisure within a period. Formally, by positing within-period nonseparable preferences, the problem is presented as follows:

$$\max_{C_i, L_i} \quad E_t \sum_{i=1}^{T-t} \beta^i U(C_{t+i}, L_{t+i}, z_{t+i}) \tag{7}$$

$$\textit{subject to} \quad \sum_{j=1}^{N} A_{t+i+1}^{j} = \sum_{j=1}^{N} A_{t+i}^{J}(1 + r_{t+i}^{j}) + y_{t+i} - C_{t+i} \tag{8}$$

where C represents consumption, L represents leisure and y is labour income. The utility function is also a function of a vector of observable variables z. The expectation operator E_t is conditional on information at time t and is taken over future uncertain labour income and interest rates. Every individual has the option of investing in N different assets A^i that pay a rate of return r_t^i at the end of period t.

Two of the first order conditions of the above optimization problem form the Euler equation:

$$U_{C_t} = E_t[U_{C_{t+1}} \beta(1 + r_{t+1}^{j})] \tag{9}$$

Equation (9) holds for the m (m≤N) assets for which is possible to borrow and lend at the same rate and for which the consumer is not at a corner. Hall (1978) used this equation to derive the random walk property of consumption. These can be derived for the level of consumption if utility is assumed to be quadratic or, under some distributional assumptions, for its log if utility is isoelastic.

Euler equation (9), following closely the methodology of Blundell et al. (1993), can also be expressed as:

$$\beta(1+r_t)U_{C_{t+1}} = U_{C_t}\varepsilon_t \tag{10}$$

where ε_t is an expectational error uncorrelated with information at time t and, by definition, has unit conditional mean, $E_t(\varepsilon_{t+1}) = 1$. By taking logs of (10) and expressing it in first differences,

$$\Delta \log U_{C_{t+1}} + \log \beta(1+r_t) = -d_{t+1} + e_{t+1} \tag{11}$$

where e_t is a random variable with zero mean and d_{t+1} reflects second and higher moments of the conditional distribution of ε_t. In terms of the empirical specification, this is represented by any individual characteristic that changes over time, e.g. demographics.

The within-period utility function is assumed to be isolestic and Cobb-Douglas between consumption and male leisure in t,

$$U(C_t, L_t) = \frac{(C_t^{\alpha} L_t^{1-\alpha})^{1-\gamma}}{1-\gamma} \tag{12}$$

Coefficient γ represents relative risk aversion. If its value is greater (less) than one, then within-period consumption and leisure are Frisch substitutes (complements). To see this more clearly consider that Frisch substitutability under deterministic wages is determined by [3]

$$\left.\partial C_t \middle/ \partial w_t \right|_{\lambda_t} = -\frac{1}{u_{CC}u_{LL} - u_{CL}^2} u_{CL}\lambda_t \tag{13}$$

where λ_t is the marginal utility of income at t which is negative if u_{CL} is positive and positive when u_{CL} is negative.

From the utility function we get that

$$u_{CL}(C,L) = (1-\gamma)\alpha(1-\alpha)C^{\alpha(1-\gamma)-1}L^{(1-\alpha)(1-\gamma)-1} \tag{14}$$

which is negative if $\gamma > 1$, indicating that within period consumption and leisure are Frisch substitutes and that they are Frisch complements when the opposite holds.[4]

The elasticity of intertemporal substitution for leisure is given by

$$\eta^l = \frac{1-\alpha(1-\gamma)}{\gamma} \tag{15}$$

[3] This can be derived assuming an interior solution for leisure. See, for example, Low (1999) for a more detailed exposition.

[4] When wages are not determined, then a high relative risk aversion increases utility smoothing and within period consumption and leisure are effectively substitutes. A low relative risk aversion parameter decreases utility smoothing under uncertainty, constituting within-period consumption and leisure complements.

The first difference of the log of the marginal utility of consumption, which is what we wish to estimate, is given by:

$$\Delta \log U_{C_t} = [\alpha(1-\gamma)-1]\Delta \log C_t + (1-\alpha)(1-\gamma)\Delta \log L_t \tag{16}$$

Hence, the parameters we set to estimate are: (α, γ). Nonseparability between consumption and male leisure is expressed by (16), that is by positing nonseparable preferences of the form implied by (12) and computing the marginal utility function based on estimated values of the (α, γ), the estimation of which relies on the estimation of the Euler equation presented below.

Using the particular form of the utility function reduces the Euler equation (9) to,

$$C_t^{\alpha(1-\gamma)-1} L_t^{(1-\alpha)(1-\gamma)} e^{\theta' Z_t} = \beta E_t[(1+r_{t+1}) C_{t+1}^{\alpha(1-\gamma)-1} L_{t+1}^{(1-\alpha)(1-\gamma)} e^{\theta' Z_{t+1}}] \tag{17}$$

which in terms of equation (11) is written as:

$$\Delta \log C_{t+1} = cons\tan t + \zeta_1 \Delta Z_{t+1} + \zeta_2 \Delta \log L_{t+1} + \zeta_3 \log(1+r_{t+1}) + e_{t+1} \tag{18}$$

where $\zeta_1 = \frac{\theta}{1-\alpha(1-\gamma)}$, $\zeta_2 = \frac{(1-\alpha)(1-\gamma)}{1-\alpha(1-\gamma)}$, $\zeta_3 = \frac{1}{1-\alpha(1-\gamma)}$.

The Z's represent demographics, often called taste shifters' because they are variables that affect the desirability for consumption at different points in the life cycle. The usual candidate variables for this are demographic characteristics, such as family size and number of children. Estimating an Euler equation in its empirical form of (18) will give us estimated values for α and γ.

4. EMPIRICAL RESULTS

4.1 Data and descriptive statistics

The Consumer Expenditure Survey (CEX) has been conducted annually since 1980 by the Bureau of Labor Statistics, which interviews households every quarter. The same household is interviewed for four consecutive quarters and then replaced by a new one. Specifically, 80% of the households are interviewed again the next quarter, whereas the other 20% are replaced by new households, randomly selected. The survey collects information on personal characteristics, household characteristics, income and expenditure.

Since the CEX is not a full panel, one could create a pseudo-panel by dividing the sample into cohorts. For this exercise, birth-year cohorts are created, thus following groups of households belonging in the same age range over the years available from the CEX, 1980-98. Because we are using the intertemporal substitution model, it makes sense to model the behaviour of individuals over their life-cycle. The constructed cohorts are the next best alternative in the absence of information on the same individuals (or households) since they track the behaviour of a group of individuals born over the same period. The empirical results presented in the following sections are based on quarterly series for each cohort for each of the years considered. In order to create the quarterly series the values for each variable in the quarter of a given year are averaged over each household belonging to a specific cohort.

In total, twelve birth cohorts are created, of which only seven are used in the estimation of both the Euler equation and the model used to test the perfect insurance hypothesis. Too young and too old cohorts are excluded from the sample. The oldest individual (head of the household) in the cohorts finally used is 70 years old and the youngest is 21. Table 1 explains the cohorts created and indicates with blanks the cohorts which are not used for the estimations.[5] The sample is further restricted by excluding households in rural areas (they were not part of the CEX survey in the years 1982 and 1983), households residing in student housing and households with incomplete income responses. Also, for the estimations, the sample includes only married couples with a male head working.

[5] The choice of the age limit used follows the cohorts used in estimation by Attanasio and Weber (1995) for reasons of direct comparability of the regression results.

TABLE 1: The definition of the cohorts

Cohort	Year of Birth	Age in 1980	Age in 1998	Average Cell Size
1	1960-64	16-20	-	-
2	1955-59	21-25	39-43	358
3	1950-54	26-30	44-48	495
4	1945-49	31-35	49-53	553
5	1940-44	36-40	54-58	427
6	1935-39	41-45	59-63	345
7	1930-34	46-50	64-68	322
8	1925-29	51-55	69-73	333
9	1920-24	56-60	-	-
10	1915-19	61-95	-	-
11	1910-14	66-70	-	-
12	1905-09	71-75	-	-

Before proceeding with the empirical results, it is interesting to see what the data says on life-cycle consumption, income and hours worked. All the figures that follow were constructed based on average annual cohort values. The first figure, Figure 1, plots the log of household nondurable consumption against the age of the reference person, i.e. the husband.

These figures can show the pattern of life cycle behaviour exactly because the data are grouped by the year of birth rather than by age and the advantage of this is obvious. We follow groups of individuals over time that were born in the same year and therefore age at the same time. Studying age profiles by pooling together several cross sections and grouping by age is potentially very misleading in the presence of cohort effects.

Figure 1: Log consumption life-cycle profile

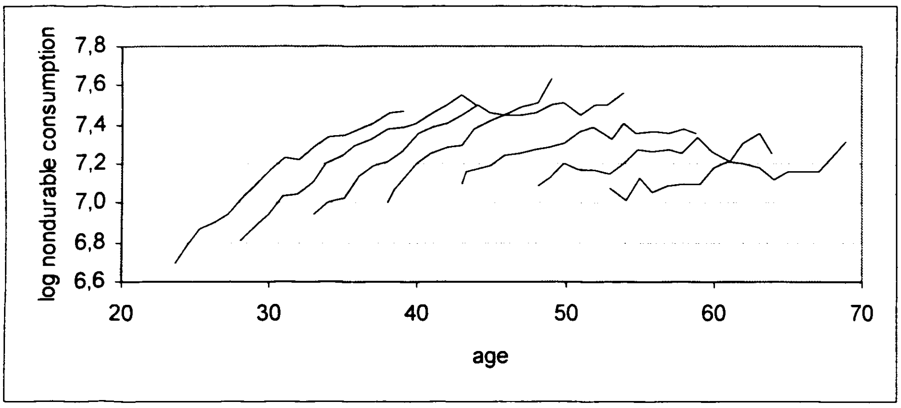
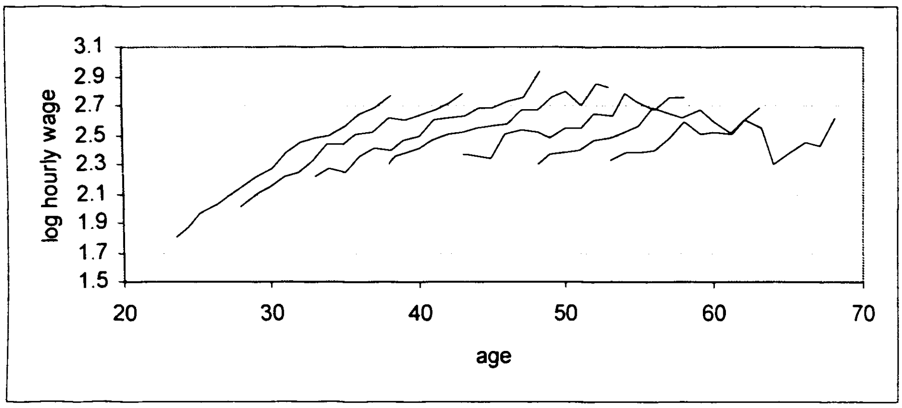


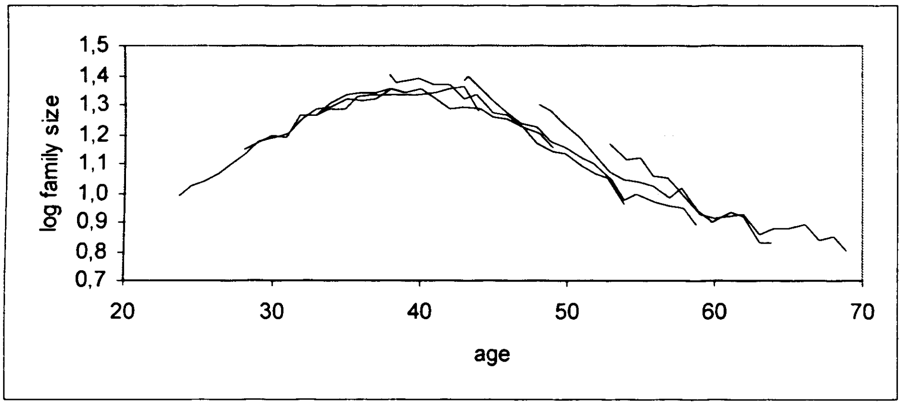
Figure 2: Log male hourly wage life-cycle profile



The connected line segments represent the consumption of one cohort, and cohorts overlap with one another by construction. As the figure shows, there is a hump in consumption that peaks before retirement. This hump is also evident in Figure 2 which plots the log of male hourly wage of the head of the household against the age of the same person. Whether the hump in the consumption profile is only due to the hump in the hourly wage profile is not all that clear if we look at the next three figures. Figure 3 shows the evolution of the family size profile, which is then dissected in two pieces in Figures 4(a) and 4(b).

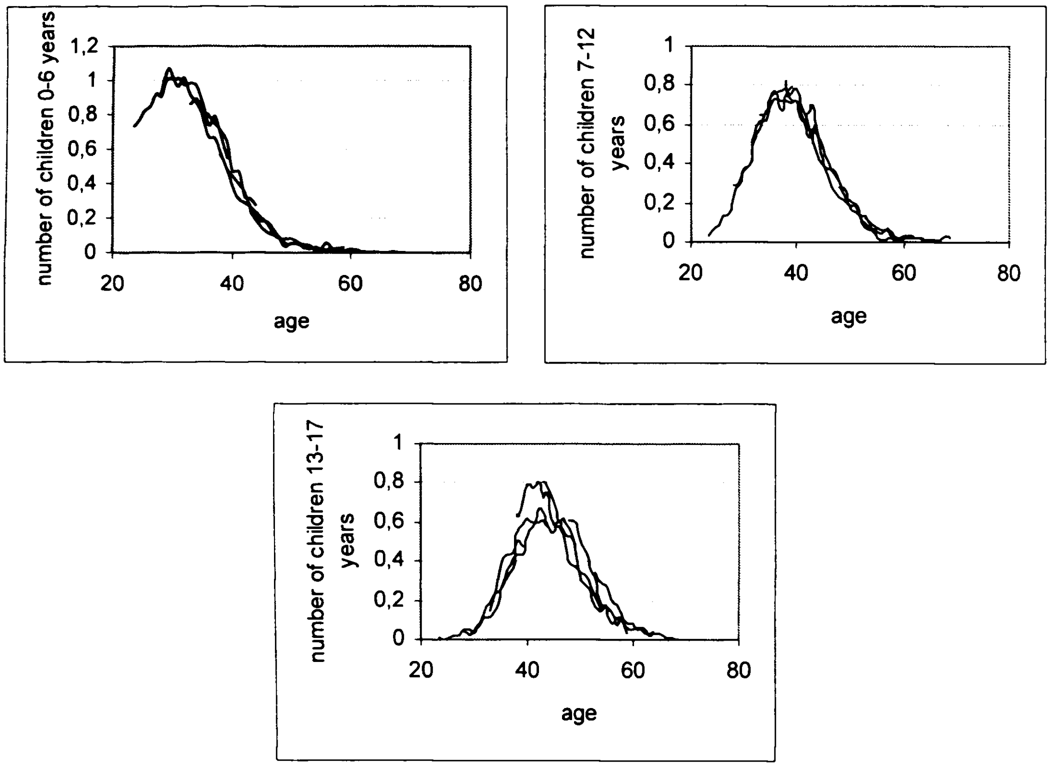
Figure 3 shows that there is also a profound hump in the log of the family size profile as well. The three figures comprising Figure 4, simply show that young children, and specifically children aged 0 to 6 years, come early in a couples' life, and particularly in their late 20's and early 30's, in contrast with older children of age 7 to 12 and 13 to 17. Couples have teenage children in their 40's, which is the same age as when household consumption increases, along with the hourly wage of the head of the household.

Figure 3: Log family size life-cycle profile



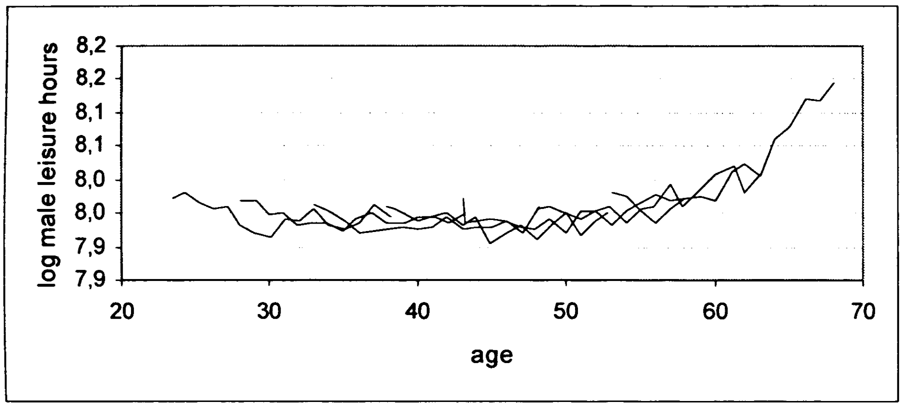
Finally, Figure 5 plots the log of leisure hours of the husband in his life-cycle. Following Attanasio and Weber (1995), available hours for work and leisure in each period is constrained to be 5,000 per year. Time spent for leisure by each individual is, therefore, computed as 5,000 minus the hours of work.

Figure 4: Number of children profile



Combining the information in Figures 4(a), 4(b) and Figure 5, it is evident that the head of the household increases his labour supply just about at the same time when he has older children in the household to provide for (people in the 30's and 40's). So, male household heads increase their labour supply and at the same time their hourly wage rises too. Because the sample refers only to married couples, this goes to show that married male heads give a lot of importance to their working careers, giving them the chance to increase their labour income due to both increased labour supply and increase of their hourly wage right at about the time when the family consists of the couple and their teenage children.

Figure5: Log of male leisure hours profile



4.2 The Euler equation results

The data, therefore, does not straightforwardly reject the life cycle model. However, since the consumption profile follows that of the hourly wage closely, it is worth further investigation to confirm exactly how correlated these two profiles are for the sample used. What follows is an empirical investigation that aims to identify the variables that determine the evolution of consumption and, hence, test the consumption insurance hypothesis.

In estimating (16), as explanatory variables the following variables are used: family size, number of children, number of children in three age categories, which are children aged 0-6, children aged 7-12 and children aged 13-17, a dummy for the working wife, three seasonal dummies. All variables in the estimation, with the exception of seasonal dummies, are instrumented since some are considered choice variables determined simultaneously with consumption and also because of measurement error induced by the size of the sample. The Treasury bill rate is used as the measure for the interest rate. Table 2 presents the estimation results of the linear Euler equation, together with tests for overidentifying restrictions and serial correlation and the estimated values for α, γ and the intertemporal elasticity of leisure.

The table presents the estimation results of three identical specifications, different only in the estimation method used, GMM, OLS and IV. All regressions omit the younger and older cohorts of the sample in order to avoid issues of liquidity constraints and retirement decisions. Estimation by GMM and IV use the same set of instruments. These are the second, third and fourth lags of consumption growth, family size, number of children, leisure, dummy for working wife, nominal interest rate, age of head of household, age of head squared, second and third lags of the number of earners in the household, and three seasonal dummies. The construction of the instruments takes into account the rotating structure of the CEX survey and while the variables used in the estimation are constructed using all available observations, the instrument variables are constructed so as to avoid overlap of households used for the instruments and the households used for the estimated equations[6].

The first estimation is conducted by GMM. This estimation method is deemed as the most appropriate with the specific data constructed in averages of birth cohorts. The reason for this is that the number of observations of each cohort in each specific quarter is rather small. Averaging over cells of relatively small size induces measurement error in the levels of the constructed variables due to "outliers" present in the cohorts in a specific quarter (i.e. a very rich - resulting in a positive measurement error in period t and a negative in period $t+1$ - or a very poor household - with the opposite result). The estimated specifications use the first differences of the constructed variables, and hence the error term consists of an MA(1) component with coefficient of -1 in addition to a white-noise component. The sum of the two error components results in an MA(1) process. Due to this error structure, the instruments used are second lags and above of the first differenced variables.

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[6] More specifically, following the methodology in Attanasio and Weber (1995), households at the fourth interview are used in construction of lag 2 instruments, households at the fourth and third interviews are used in construction of lag 3 instruments, and households at the first interview are excluded from lag 4 instruments.

TABLE 2: GMM, IV and OLS Euler equation estimation results

Variables	Cohorts 2-8 (Omitting young and old cohorts)		
	GMM	OLS	IV
Constant	0.0096	0.0105	0.0122
	0.0110	*0.0072*	*0.0129*
Real interest rate	0.2110	0.1253	0.1503
	0.1753	*0.1161*	*0.2094*
Δ log(family size)	-1.3849	0.2526	-0.8022
	0.5965	*0.1085*	*0.6361*
Δchildren 0-6 years	0.2431	-0.0521	0.1095
	0.2563	*0.0634*	*0.2977*
Δchildren 7-12 years	0.2922	0.0013	0.0784
	0.3280	*0.0603*	*0.3993*
Δchildren 13-17 years	1.0406	0.0267	0.9238
	0.3240	*0.0635*	*0.3869*
Δ dummy for working wife	-0.2987	0.1417	-0.5708
	0.4217	*0.0724*	*0.4346*
Δ log(men's leisure hours)	-0.4626	-0.0200	-0.5559
	0.2293	*0.0385*	*0.2188*
Estimated α	**0.6304**	**0.8137**	**0.6045**
	0.1221	*0.0342*	0.1024
Estimated γ	**6.9305**	**9.5799**	**10.3504**
	5.9564	*8.9064*	*14.7252*
Intertermporal elasticity of substitution	0.6837	0.8331	0.6427
	0.1072	*0.0268*	*0.0904*
Test for overidentifying restrictions	14.5868	-	0.0672
(p-value)	*0.56*	-	*0.99*

Table 2 presents the three estimation results. In the first column of the table, the GMM estimation, the coefficient on the interest rate is 0.2, although it is not statistically significant. In fact, the coefficient of the interest rate is never precisely estimated in any of the specifications. The coefficient on leisure is negative at -0.5 and significant. Older children aged thirteen to seventeen years play a positive and significant role in consumption growth with a coefficient of 1.04. Family size is also significant, albeit negative. However, it should be noted that the coefficient of family size cannot be completely separated from the coefficients of the children variables. The dummy indicating whether the wife is working, or not, is not significant. The p-value for the test of the overidentifying restrictions allows us to accept the overidentifying restrictions.

The parameters of interest (α, γ) and η given by the GMM estimation are 0.6, 6.9 and 0.7 respectively. The estimates on the relative risk aversion and the intertemporal elasticity of substitution seem rather large.[7] As far as the intertemporal elasticity of substitution is concerned, the empirical evidence on its magnitude is diverse, but the result presented for the GMM estimation in Table 2 does agree with some of the evidence based on work using average cohort techniques (for example, Attanasio and Weber (1993) estimated an intertemporal substitution elasticity as high as 0.8 using the British Family Expenditure Survey).

The specification in the second column reports the results from the OLS estimation. The parameter estimates are generally lower than those in both the IV and GMM estimations. Also, the GMM estimator is heteroskedasticity adjusted, and so more efficient than the simple IV estimator. The parameters of interest (α, γ) and η, are considerably higher as a result. Accordingly, the estimates from the GMM estimation are generally higher than those

[7] Other studies have found large values for the relative risk aversion parameter, e.g. Constantinides (1990).

from the IV estimation. The significance of the interest rate variable and of the male leisure variable is not changed in the OLS and IV estimation compared to the GMM estimation, but the significance of the family composition variables changes.

4.3 The intertemporal optimization model results

Table 3 summarizes the results from the estimation of equation (6). The dependent variable is constructed based on the results of the Euler equation. More specifically, the dependent variable is the first difference of the log of marginal utility of consumption and is given by equation (16), where C_t is total non-durable consumption and L_t is male leisure hours. Also demographics are used and these are the same as the ones included in the Euler equation, i.e. family size, number of children in the three different categories and dummy for the working wife.

For the income measure, two measures could be considered. Firstly, labour income could be used before taxes. Unfortunately, labour income after taxes cannot be constructed.[8] Labour income is calculated as total income minus capital income. Secondly, male hourly wage could be used in the specifications presented below in Table 3, and this is what is actually chosen in the final estimations. The use of the hourly wage is the more appropriate

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[8] Income data are collected at the first and last interviews and refer to the previous twelve months. Labour income is also computed at the second or third interview if a member of the household reports changing their employment.

measure to use in this context because one can argue that systematic relative wage movements across large groups of workers are uncorrelated with idiosyncratic components of individual-level preference shifts, i.e. changes in health status or household composition. Both of the latter affect both the individual earnings capacity and household marginal utility, and so could lead to false rejections of consumption insurance hypothesis (see Cochrane (1991)). In the context of non-separability used in this paper, the use of labour income seems all the more inappropriate since it could be correlated with the male leisure hours included in the construction of the dependent variable of the estimated specifications.

Each of the three columns of Table 3 presents the results from four identical specifications which differ only in the estimation method and the time horizon of the data. Estimation is conducted by OLS using the quarterly average cohort data and also by using the annual average cohort specification. This aims to investigate whether allowing for a longer time horizon provides more evidence in favour of the consumption hypothesis. The same procedure is followed for the instrumental variables specification. The instrument strategy used for the quarterly specification is the same as in the previous section. In the case of the first differenced annual specification, the instruments one can use are third differences of the log of hourly wage, third differences of the variables used to construct the dependent variable and third differences for the demographic variables.

TABLE 3: Intertemporal optimization model results

Variables	Cohorts 2-8 (Omitting young and old cohorts)			
	OLS	IV	OLS	IV
	Annual series		Quarterly series	
Constant	0.0426	0.0418	0.0238	-0.0799
	0.0038	*0.0048*	*0.0380*	*0.0652*
Δ log (hourly wage)	-0.0122	0.0087	0.0018	0.2950
	0.0205	*0.0467*	*0.0179*	*0.1125*
Test for overidintifying restrictions	-	0.6921	-	23.6185
(p-value)	-	*0.8751*	-	*0.0982*

The first column reports the OLS estimation results where the dependent variable is constructed based on the results of the GMM Euler equation results. All specifications include time dummies. The results based on the quarterly series indicate that the consumption insurance hypothesis is rejected, both in the OLS and the IV estimation results. In contrast, the annual estimation results do not provide evidence against the consumption insurance hypothesis. The response of consumption changes to relative wage changes is also much less when a longer time horizon is allowed for. This provides evidence that individuals are more likely to smooth consumption in the long-run than in the short-run and one reason commonly attributed to this is that people face stronger liquidity constraints in the short-run.

However, it is not exactly clear whether for even longer time periods would still show evidence against no consumption smoothing, since other studies found that one year differences do not show evidence against consumption insurance, but longer time differences contradict the hypothesis[9]

5. CONCLUSIONS

This paper uses the Consumption Expenditure Survey for the years 1980-1998 to test the consumption insurance hypothesis under non-separability between within-period consumption and leisure. A Cobb-Douglas utility function is specified that is isoelastic and nonseparable between consumption and leisure. An Euler equation approach is adopted where the results from the Euler equation of consumption are used to construct the growth of the log of marginal utility to be finally be used to test the consumption insurance hypothesis. The Euler equation stems from the nonseparability in consumption and leisure utility function and the aim is to investigate whether the restrictive way in which leisure enters the equation for the growth of consumption affects the acceptance or rejection of the theory.

Synthetic cohort construction is implemented as the next best alternative to a full panel dataset. The sample is restricted to married couples with a male

[9] Attanasio and Davis (1996), for example, find that one year consumption changes are not explained by corresponding changes in hourly wage, whereas eight-year consumption changes were the dominant force behind the changes in the distribution of household consumption.

working head. The sample is further restricted by excluding younger and older cohorts in the sample in an attempt to avoid liquidity constraints and retirement decisions. The results indicate towards a rejection of the consumption insurance hypothesis in the first differenced quartarly specification. It would also be interesting to see whether the construction of cohorts according to birth year and education level provides even stronger evidence against the hypothesis.

Where could one go from here? The above framework, despite modelling intratemporal nonseparability between consumption and leisure, it ignores intertemporal separability. Issues such as habit formation and durability that induce a certain form of dynamics to consumption are not formally modeled. Utilizing the dynamic demand system framework, one could test for intertemporal separability and also identify the restrictions under which the problem can be expressed in the Euler equation approach. The analysis would incorporate consumption on durables and habit formation and investigate how it could be extended to include leisure. One could have a system of equations, namely expenditure on durables, expenditure on non-durables and finally an equation for leisure. This would then enable analysis for including social security and investigate a number of issues, like retirement decisions.

REFERENCES

Altug, S., and R.A. Miller (1990), "Household Choices in Equilibrium", *Econometrica*, 58, 543-570.

Attanasio, O.P. (1999),"Consumption" in *Handbook of Econometrics*, 1, Taylor, J.B. and M. Woodford, ed., Elsevier Science B.V.

Attanasio, O.P., and S. J. Davis (1996), "Relative Wage Movements and the distribution of consumption", *Journal of Political Economy*, 104 1227-1262.

Attanasio O.P., and G. Weber (1995), "Is consumption growth consistent with intertemporal optimization? Evidence from the Consumer Expenditure Survey ", *Journal of Political Economy*, 103, 1121-1157.

Attanasio O.P., and G. Weber (1993), "Consumption growth, the Interest Rate and Aggregation ", *Review of Economic Studies*, 60, 630-649.

Blundell, R. (1988), "Consumer Behaviour: Theory and Empirical Evidence- A Survey", *The Economic Journal*, 98, 16-65.

Blundell, R., C. Meghir and P. Neves (1993), "Labour Supply and Intertemporal Substitution", *Journal of Econometrics*, 59, 137-160.

Blundell, R., M. Browning and C. Meghir C (1994), "Consumer Demand and the Life-Cycle Allocation of Household Expenditures", *Review of Economics Studies*, 61, 57-80.

Blundell, R., and I. Walker (1982), "Modelling the Joint Determination of Household Labour Supplies and Commodity Demands", *Economic Journal*, 92, 351-364

Browning, M., A. Deaton, and M. Irish (1985), "A profitable approach to labour supply and commodity demands over the life cycle", *Econometrica*, 53, 503-544.

Browning, M., and C. Meghir (1991), "The Effects of Male and Female Labour Supply on Commodity Demands", *Econometrica*, 59, 925-951

Cochrane, J.H. (1991), "A Simple Test of Consumption Insurance", *Journal of Political Economy*, 5, 957-976.

Constantinides, G.M. (1990), "Habit Formation: A Resolution of the Equity Premium Puzzle", *Journal of Political Economy*, 98, 519-543.

Deaton, A. (1992), *Understanding Consumption* (Oxford University Press, Oxford).

Flavin, M. (1981), "The adjustment of consumption to changing expectations about future income", *Journal of Political Economy*, 89, 974-1009.

Friedman, M. (1957), *A Theory of the Consumption Function* (Princeton University Press, Princeton, NJ).

Hall, R.E. (1978), "Stochastic Implications of the Life Cycle-Permanent Income Hypothesis: Theory and Evidence", *Journal of Political Economy*, 86, 971-987.

Hotz, V.J., F.E. Kydland and G.J. Sedlacek (1988), "Intertemporal Preferences and Labour Supply", *Econometrica*, 56, 335-360.

Keynes, J.Maynard (1936), *The general theory of employment, interest and money*, London: MacMillan.

Kuznets, S., (1951), "Long-Term Changes in the National Income of the United States of America since 1870", in *Income and Wealth of the United States: Trends and Structure*, International Association for Research in Income and Wealth, *Income and Wealth, Series II*, Bowes & Bowes, Cambridge (England).

Low, H. (1999), "Self-Insurance and Unemployment Benefit in a Life-Cycle Model of Labour Supply and Savings", Institute for Fiscal Studies, Working Paper Series, No. W98/24.

Mace, B. (1991), "Full Insurance in the Presence of Aggregate Uncertainty ", *Journal of Political Economy*, 5, 928-956.

Meghir, C., and G. Weber (1996), "Intertemporal Non-Separability or Borrowing Restrictions? A Disaggregate Analysis Using a U.S. Consumption Panel", *Econometrica*, 64, 1151-82

Modigliani, F., and R. Brumberg (1954), "Utility Analysis and the Consumption Function: An Interpretation of cross-section data", in K.K. Kurihara, ed., *Post-Keynesian Economics* (Rutgers University Press, New Brunswick, NJ) 128-197.

CHAPTER 2

THE EFFECT OF HOUSEHOLD HETEROGENEITY IN A DYNAMIC SPECIFICATION OF COMMODITY DEMAND

ABSTRACT. The purpose of this paper is to test the effect of observed heterogeneity in the evidence for the presence of habit formation and durability in commodity demands. The proposed model is a dynamic version of the Almost Ideal Demand System applied to the UK Family Expenditure Survey data over the period 1987-2001 using average cohort techniques. The dynamic AI demand system is estimated for four commodity groups both with and without household observed heterogeneity measures. Observed household heterogeneity is expressed with demographic, education and marital status variables in the share equations. The effect of household heterogeneity is discussed on the evidence of dynamics, the allocation of expenditure to consumer goods and budget and price elasticities. Time dependence cannot be rejected in both models.

1. INTRODUCTION

The purpose of this paper is to investigate the effect of observed household heterogeneity on commodity demands in a dynamic context. The notion that demand decisions are not time-separable is not new in the literature and it has been investigated in a wealth of contexts. The issues studied range from demand systems (Muellbauer and Pashardes (1992), Anderson and Blundell (1982), Stoker (1986), Alessie and Kapteyn (1991), Browning (1991), Weissenberger (1986)), to the equity premium puzzle (Constantinides (1990)) and the excess sensitivity and the excess smoothness of consumption to permanent income shocks (Attanasio and Weber (1995), Browning and Collado (2001)). Time nonseparability is introduced through habit formation and durability, two of the most important factors that introduce intertemporal nonseparability. Much of the early work has been conducted on the aggregate level, mainly due to the unavailability of appropriate microeconomic data for dynamic analysis. To infer dynamic properties of demand on the micro level one has to have individual panel with information on total consumption and individual characteristics. Usually, the available panel datasets do not combine the two effectively, and if they do it is for a limited time span.

Two of the most important cases when intertemporal separability is violated are that of durable goods and habit formation. Time dependence of preferences implied by durability and habit formation is one of the things that complicate discussion. The literature on habit formation and durability and the dynamic properties they implicate for demand systems goes back more than three decades. The early work introduced habit formation and durability in a myopic framework (Houthakker and Taylor (1966, 1970), Pollak and Wales (1969), Taylor and Weiserbs (1972), Phlips (1972), Gorman (1967), Pollak (1970, 1976, 1978)). Consumers recognize that current consumption depends on past consumption, and thus on past habits, but does not take into account the effect of current consumption on future preferences. Rational habit formation, on the contrary, does take the latter effect into account and such models were developed by Lluch (1974) and Phlips (1974). However, Spinneweyn (1981) was the first to present a simplified approach by acknowledging that a redefinition of the cost of consumption and wealth (user cost concepts) makes a model with rational habit formation equivalent to a model with no habit formation. Later, Phlips and Spinneweyn (1982) showed that, under certain assumptions on expectations and preferences, myopic and rational habit formation are equivalent.

Muellbauer and Pashardes (1992) propose a model which incorporates durability and habits in the utility function that is parsimonious in parameters and estimate both the static and dynamic version of the AI demand system to fund that homogeneity and symmetry are acceptable in the dynamic form. This is a result supported in other studies of dynamic demand systems (Anderson and Blundell (1982)). A drawback of the Muellbauer and Pashardes (1992) study, as with all early work on habit formation, is the use of aggregate data which does not give room for the investigation of the effect of observed, or unobserved (fixed effects), heterogeneity on commodity demands.

Some recent notable exceptions in the literature that use microeconomic data and explore the effect of demographics and other measures of household heterogeneity are the papers by Meghir and Weber (1996), Naik and Moore (1996), Dynan (2000) and Carasco et al. (2005). Meghir and Weber (1996) use data from the Consumption Expenditure Survey (CEX) of the US that contains information on the consumption of the same households for four consecutive quarters since it is a rotating panel. They estimate the within-period marginal rate of substitution which is robust to the presence of liquidity constraints and do not find evidence of habit formation. Naik and Moore (1996) and Dynan (2000) use annual information from the Panel Study of Income Dynamics (PSID) of the US where there is information only on food consumption. The two papers reach the opposite conclusions as the first finds evidence of habit formation but the second does not. Carasco et al. (2005) argue that the results of all three papers have drawbacks arising partly from their use of data. They follow the estimation method proposed by Meghir and Weber (1996) and use it with a Spanish panel data set, with eight consecutive quarters of available information on contrast to the four available in the CEX, and find evidence of habit formation in the demand system of food at home, transport and services. Their results rely on the fact that they are able to control for unobserved heterogeneity in their data due to the time span available.

This paper uses data from the UK Family Expenditure Surveys from 1987 to 2001 and estimates a dynamic Almost Ideal Demand System. The framework of analysis adopted is that of Muellbauer and Pashardes (1992), taking it one step further by taking into account household heterogeneity. The latter is expressed as a group of variables z_{it} (for household i at time t). Total consumer expenditure, included in the budget share equations of the

AI demand system is not considered to be endogenous with household characteristics since we do not include employment variables in order to avoid endogeneity problems. Female employment, in particular, has been found to be highly correlated to the presence of children in the household (e.g. Browning and Meghir (1991), Mroz (1987)).

The analysis is based on average cohort techniques constructed according to the age of the head of the household. This has some implications on the dynamic analysis performed in the sense it is expected to weaken time dependence results on commodity demands. However, it is useful to note here that although panel data would be the appropriate ones to use in dynamic analysis, it is a fact that a good panel dataset with an adequate length of time periods is not available as yet. In contrast, there is a wealth of good quality cross-sectional data available for large periods of time, and one of these datasets, the UK FES is used in this study.

Section 2 describes the model and derives the formulas for estimating the price and expenditure elasticities. Section 3 describes the data and presents the empirical specification and the estimation results. Finally, Section 4 concludes.

2. MODEL SPECIFICATION

The standard way to derive a demand system is by assuming each consumer has the following intertemporal utility function:

$$U = U(q_{1t},\dots,q_{nt},\dots,q_{1T},\dots,q_{nT}) \tag{1}$$

The corresponding life-cycle budget constraint is

$$W_t = \sum_{i=1}^{n}\sum_{j=t}^{T} \hat{p}_{ij} q_{ij} , \tag{2}$$

where $\hat{p}_{ij}$ is the discounted price for good i in period j expected at time t.

Such a utility function lies behind every static demand system and, with the assumption of weak separability, two-stage budgeting is possible and the consumer allocates expenditures e_t across periods and then maximizes

$$u = v(q_{1t}, q_{2t},\dots,q_{nt}), \tag{3}$$

in each period of life subject to the budget constraint

$$\sum_{i=1}^{n} p_{it} q_{it} = e_t , \tag{4}$$

where e_t is total expenditure at time t.

In Muellbauer and Pashardes (1992) durability is introduced by defining the stock of good i in period t as:

$$S_{ij} = q_{ij} + d_i S_{ij-1} , \tag{5}$$

where in each period the consumer adds quantity q of food i to a proportion d of the stock remaining from last period. If the consumer develops habits then consumption in each period must be higher than last period's consumption, in order for consumption to contribute the same to utility. This is expressed by a variable z_{ij} which should replace q_{ij} as follows:

$$z_{ij} = S_{ij} - a_i S_{ij-1} \tag{6}$$

where $0 \leq a_i < 1$ and which can be expressed as a function of q_{ij} if we replace (5) in place of S_{ij}.

In essence, the consumer minimizes the life-time budget constraint (2), s.t. (1), (5) and (6). The life time budget constraint can be written explicitly by defining a discounting factor:

$$\sum_{j=0}^{\infty} \sum_{i=1}^{n} (1/(1 + r_{t+j}))^{j} p^{e}_{it+j} q_{it+j} \tag{7}$$

where one more issue is introduced, that of price expectations, expressed by p^{e}_{it+j}, which is the expected price of good i at time t+i expected at time t. We will specify the price expectations generating process in Section 4.

The Lagrangian associated with (7) under the restrictions (1), (5) and (6) is:

$$L = \sum_{j=0}^{\infty} (1 + r_{t+j})^{-j} \{ \sum_{i=1}^{n} p^{e}_{it+j} \left(S_{it+j} - d_i S_{it+j-1} \right)$$

$$-\lambda_{t+j}[U(S_{1t+j}-a_1S_{1t+j-1},\ldots,S_{nt+j}-a_nS_{nt+j-1})-U_{t+j}\} \quad (8)$$

where λ_{t+j} is the Lagrangian multiplier in period $t+j$.

The first order condition derived from (8), solving for the S_{ij}'s is:

$$L=(1/(1+r_{t+j}))^j p^e_{it+j}-(1/(1+r_{t+j}))^j\lambda_{t+j}\frac{\partial U}{\partial z_{it+j}}-(1/(1+r_{t+j+1}))^{j+1}p^e_{it+j+1}d_i$$

$$+(1/(1+r_{t+j+1}))^{j+1}\lambda_{t+j+1}a_i\frac{\partial U}{\partial z_{it+j+1}}=0,\ i=1,2,\ldots,n \quad (9)$$

Dividing (9) by $(1/(1+r_{t+j}))^j$ and by assuming that the real discount rate is constant[10] we get the following expression for the Euler equation:

$$\lambda_{t+j}\,\partial U/\partial z_{it+j}=p'^e_{it+j}+(1/(1+r_{t+j+1}))a_i\lambda_{t+j+1}\,\partial U/\partial z_{it+j+1} \quad (10)$$

where $p'^e_{it+j}=p^e_{it+j}-(d_i/(1+r_{t+j+1}))p^e_{it+j+1}$. (11)

Equation can be evaluated for a finite period, i.e. for values of j from 0 to T, and the system can then be solved recursively and it is easy to show that:

$$\lambda_t U_{z_{it}}=\sum_{j=0}^{T}p'^e_{it+j}(a_i)^j+(a_i/1+r)^{T+1}\lambda_{t+T+1}U_{z_{it+T+1}} \quad (12)$$

If we let $T\to\infty$ Equation (12) reduces to

[10] This is a common assumption in dynamic analysis.

$$\lambda_t U_{z_{it}} = \sum_{j=0}^{\infty} p'^{e}_{it+j} (a_i)^j \qquad [11] \qquad (13)$$

At this point we introduce price expectations. The most common assumption in empirical work (and theoretical work concerning the dynamic version of demand systems) is that price expectations are constant. In other words consumers expect relative prices to remain the same in all periods. A more realistic assumption that complicates the analysis albeit in a minor way is that prices follow an AR(1) process

$$p_{it+1} = \xi_i + \rho_i p_{it} + \eta_{it+1}, \ \forall i, \qquad i=1,\dots,n \qquad (14)$$

where η_{it+1} an i.i.d. error term with zero mean. For infinite periods, solving recursively (14) leads to the expectation at time t of the price prevailing at time *t+j*

$$p^{e}_{it+j} = \xi_i (1-\rho_i^{\,j}) \Big/ (1-\rho_i) + \rho_i^{\,j} p_{it} \qquad (15)$$

Using (14) and (15) in solution (13) will give us the expression we seek, namely the expression that relates p'_{it} to p_{it}. Some brief algebra leads to the following expression[12]

$$p'_{it} = p_{it}\left(1-(d_i\rho_i/(1+r) \Big/ 1-(a_i\rho_i/(1+r) \right) + f(\xi_i,\rho_i,a_i,d_i,r) \qquad (16)$$

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[11] This makes use of the transversality condition which states that the shadow value of the marginal utility goes to zero as T goes to infinity.

[12] For a detailed exposition see Berstein et al. (1999).

where

$f(\xi_i, \rho_i, a_i, d_i, r)$ is a linear function of its parameters which will be represented by the parameter ϕ_i.

In the case when expectations are taken to be constant, (16) reduces to

$$p'_{it} = p_{it}((1+r-d_i)/(1+r-a_i)), \tag{17}$$

which is exactly the one used in the Muellbauer and Pashardes (1992) paper, and it is something that will be maintained in this paper too, for direct comparability.

The above solution derived from expressing the problem as an Euler equation as was done in the exposition above is the same with that taken from minimizing the budget constraint facing the consumer in a given period,

$$\min \sum_i p'_{it} z_{it}, \tag{18}$$

where p'_{it} equals the right side of (13) by construction, subject to the utility function expressed using effective quantities $u = u(z_{it},...z_{nt})$ and using the Sheppard's lemma to obtain quantity demanded. Therefore, we do not need to estimate the actual Euler equation (13) itself. Instead, we solve the problem defined by (18) to reach the same first order conditions given by

(13). Following that, the optimized value of (18) is the cost function defined by $C(p'_{1t},...,p'_{nt},u_t)$. By applying Sheppard´s Lemma it is possible to obtain the unobservable quantities $z_{it} = \partial C/\partial p'_{it}$. These can be expressed in terms of the observable quantities $q_{it} = \partial C/\partial p'_{it} + (a_i - d_i)S_{it-1}$.

Duality specifies that minimization of the budget constraint equals the maximization of utility subject to the budget constraint. This is the procedure followed by Muellbauer and Pashardes (1992) which will be replicated here. Households decide how to allocate expenditure across goods and services and the problem the consumer has to solve is given by

$$Max\ u(z_{it}, z_{2t},..., z_{nt}) \tag{19}$$

$$s.t.\ p'z = x$$

where $z = (z_1,...,z_n)$ is a vector of n effective quantities of goods and services, $p' = (p'_1,...,p'_n)$ is the vector of corresponding adjusted prices.

Solving (19) gives the Marchallian (uncompensated) demand functions

$$z_{it} = g_i(p'_t, x_t) \tag{20}$$

Since $z's$ and l' are not observable, equations (19) and (20) are expressed in terms of the observables $q's$ and l as it is done below

$$q_{it} = g_i(p'_t, x_t) + (a_i - d_i)S_{it-1} \tag{21}$$

Elasticities

Equation (21) is the Marshallian demand for good (or commodity group) *i*, and by using a reparametrization of effective quantities,

$$z'_{it} = z_{ih}(1 - a_i)/(1 - d_i) \tag{24}$$

which has the attribute that z'_{it} equals q_{it} in the steady-state, it can be rewritten as

$$q_{it} = ((1 - a_i)/(1 - d_i))g_i(p'_t, x_t) + (a_i - d_i)S_{it-1} \tag{25}$$

For simplicity, let us ignore durability for a few steps ahead, so that $d_i = 0$ and $S_{it} = q_{it}$. Also, let us remember that $p'_{it} = \lambda_i p_{it}$, where $\lambda_i = (1 + r - d_i)/(1 + r - a_i)$. A reparametrization of habits can be defined by multiplying z_{it} by $(1 - d_i)/(1 - a_i)$, and call them z'_{it} so that in the steady state effective quantities equal actual quantities, and consequently redefine λ_i by $\lambda'_i = \lambda_i(1 - a_i)/(1 - d_i)$.

In share form, equation (27) is written as

$$w_{it} = (1-a_i)w'_{it}(x_t/\lambda'_i e_t) + a_i q_{it-1}\, p_{it}/e_t \tag{26}$$

where $x_t = \sum_{i=1}^{n} \lambda_i p_{it} z'_{it}$, $e_t = \sum_{i=1}^{n} p_{it} q_{it}$, $w_{it} = q_{it} p_{it}/e_t$ and $w'_{it} = g_{it} p'_{it}/x_t$.

Own price elasticity at time t is determined by

$$e_{ijt} = \partial \ln q_{it}/\partial \ln p_{jt} = (1/w_{it})\partial w_{it}/\partial \ln p_{jt} - \delta_{ij} \tag{27}$$

where $\delta_{ij} = 1$ if $i{=}j$ and zero otherwise. Since p'_{it} is proportional to p_{it} it follows that $\partial \ln w_{it}/\partial \ln p_{jt} = \partial \ln w_{it}/\partial \ln p'_{jt}$ and at base prices, assuming that $r = 0$ (which implies that $\lambda_i = 1$), then at the steady-state

$$\partial \ln w_{it}/\partial \ln p_{jt} = (1/w_{it})[(\partial w'_{it}/\partial \ln p_{jt})(1-a_i) + \delta_{ij} a_i (q_{it}/e_t)] \tag{28}$$

Therefore,

$$e_{ijt} = [(\xi_{ij}/w_{it}) - \delta_{ij}](1-a_i) \tag{29}$$

where

$$\xi_{ij} = \partial w_{it}/\partial \ln p_{jt} \tag{30}$$

Budget elasticity is given by

$$e_{it} = \partial \ln q_{it} / \partial \ln y_t = (1/w'_{it})[(\beta_i x_t / \lambda_i e_t) + (\partial x_t / \partial e_t)(w'_{it} / \lambda'_i)$$

$$- (\partial x_t / \partial e_t)(w'_{it} / \lambda'_i) - (a_i q_{it-1} p_{it}) / e_t + 1] \qquad (31)$$

which evaluated at base prices, assuming that $r = 0$ and at the steady-state it reduces to

$$e_i = (1 - a_i)((\beta_i / w_i) + 1) \qquad (32)$$

3. EMPIRICAL SPECIFICATION AND RESULTS

The sample of the data is drawn from the UK Family Expenditure Survey for the years 1987 to 2001. Since the UK FES is not a panel, synthetic cohort technique is applied by creating 5-year birth cohorts according to the age of the head of the household.

Expenditure is divided in four broad categories for the sake of parsimony which is considered to be essential due to the small number of observations finally used for the estimations:

(a) Non-durables: food and catering, alcohol and tobacco

(b) Miscellaneous goods and services: clothing and footwear, leisure goods and services, household goods and services

(c) Energy and Transport

(d) Durables: include vehicles, electrical goods and furniture.

Housing, health, education and holiday expenditure are excluded from the analysis, and hence the analysis is conducted under the assumption that consumption is separable from these goods. The second category of commodities, named miscellaneous, groups together a considerably diverse number of goods and services. However, they were grouped together and kept separate from energy and transport because they contain goods that can be characterized by semi-durability. The energy and transport group is a purely non-durable expenditure but is not grouped together with the food and alcohol in order to see whether the model picks up habit formation in these goods and services. Most studies of habit formation on commodity demands study these goods and services separate too, so one other reason for keeping them that way is for the sake of comparability.

The dataset includes fourteen independent cross-sections of British households, for a total of 104314 observations. The survey provides a random sample of the population each year and, even if we lack a panel structure and cannot track individual households, it is possible to track groups of households.

Table 3.1: Five-years cohorts definition and average number of households in each cohort

Cohorts	Year of birth	Age in 1987	Age in 2001	Average cell size	Total
1	1971/1975	16-20	30-34	441	6621
2	1966/1970	21-25	35-39	674	10112
3	1961/1965	26-30	40-44	686	10291
4	1956/1960	31-35	45-49	646	9689
5	1951/1955	36-40	50-54	670	10047
6	1946/1950	41-45	55-59	567	8510
7	1941/1945	46-50	60-64	494	7417
8	1936/1940	51-55	65-69	492	7374
9	1931/1935	56-60	70-74	510	7652
10	1926/1930	61-65	75-79	526	7890
11	1921/1925	66-70	80-84	418	6270
12	1916/1920	71-75	85-89	310	4644
13	1911/1915	76-80	90-94	186	2793
14	1906/1910	81-85	95-99	72	1082
Total					100392

By grouping households according to the age of the household head (Browning et al. (1985)), we divide the sample into homogeneous groups and track over time the cohorts. A cohort can be defined as a group with fixed membership formed by individuals who can be identified as they show up in surveys (Deaton (1985)). Groups can be identified in various ways, as long as the membership remains constant over time. The most natural representation is to consider an age cohort formed by individuals (household heads) born in the same period. For this reason, we group the household on the basis of the head's year of birth, using five-years age bands cohorts. The definition of the cohorts, the birth years, the ages observed and the size of each cell are reported in Table 3.1. The last two cohorts are not included in the estimation process.

When considering habits we have to distinguish between three possible sources of persistence in behaviour: persistence if the environment the household faces (demographics, lifetime wealth, expectations etc), state dependence (either habits or durability) and heterogeneity. What we aim to identify here is state dependence that should not be affected by heterogeneity. It is well known that both state dependence and heterogeneity lead to persistence but for difference causes and their implications are very different. Consider, for example, smoking. The probability of smoking in the current period *t* is dependent on smoking behaviour in period *t-1*, but this could be because people are "smokers" (heterogeneity), or because something induced them to start smoking at some time and then continue (state dependence).

In order to assess the true degree of persistence, whether this is due to habits or durability, i.e. state dependence, persistence in the environment and heterogeneity have to be "taken out" of the data. In this paper, the effect on the habit and durability estimates of ignoring persistence in the environment is considered by comparing the results between two formulations: one that contains demographics and one that does not.

Even though one can argue that unobserved heterogeneity is averaged out in cohort data, there are ways to control the effects of unobserved heterogeneity at the individual level. This can be achieved by splitting the sample in sub-groups of interest, e.g. by age and education (i.e. young cohorts with low education, young cohorts with high education, and similarly for old cohorts). The only problem with this is that the resulting sub-samples may be too small for correct inference. Results should be addressed with caution. The estimation of the dynamic demand we formulate below is quite costly in itself, and the option of splitting the sample in sub-groups was not followed. However, the resulting estimation of the degree of habit persistence and durability is expected to be largely unbiased from unobserved heterogeneity, and we consider this one advantage of using cohort data.

The cost function used for the AI demand system, in its static form, is defined in the following way:

$$\log c(p, w, u) = (1 - u)\log[a(p, w)] + u \log[b(p, w)] \quad (33)$$

where

$$\log a(p, w) = \alpha_o + \sum_i^n \alpha_i \log p_i + 1/2\sum_i^n \sum_j^n \gamma_{ij} \log p_i \log p_j \quad (34)$$

and

$$\log b(p,w) = \log a(p,w) + \beta_o \prod_i^n p_i^{\beta_i} \tag{35}$$

By applying Shephard's lemma we obtain the demand equations for goods and leisure in their budget forms:

$$w_{it} = \alpha_i + \sum_{j=1}^{n} \gamma_{ij} \log p_{jt} + \beta_i \log(x_t / P) \qquad \text{for goods i=1,...n} \tag{36}$$

where price index P is the price index as defined by

$$\ln P = \alpha_0 + \sum_{i=1}^{n} \alpha_i \ln p_{it} + 1/2 \sum_{i=1}^{n} \sum_{j=1}^{n} \gamma_{ij} \ln p_{it} \ln p_{jt} \tag{37}$$

The dynamic version of the empirical specification takes the form

$$p'_{it} z'_{it} = ((1-a_i)/(1-d_i))(\alpha_i + \sum_{j=1}^{n} \gamma_{ij} \ln p'_{it} + \beta_i \ln(x_t / P_t))x_t + (a_i - d_i)S_{it-1}, \tag{38}$$

where

$$\ln P = \alpha_0 + \sum_{i=1}^{n} \alpha_i \ln p'_{it} + (1/2) \sum_{i=1}^{n} \sum_{j=1}^{n} \gamma_{ij} \ln p'_{it} \ln p'_{jt} \tag{39}$$

and

$$x_t = \sum_i p'_{it} z'_{it} \tag{40}$$

The demand system will be estimated on the budget shares which are formed as follows,[13]

$$w_{it} = p_{it}(a_i - d_i)S_{it-1} / e_t \tag{41}$$

$$+ (x_t(1-a_i)/(\lambda_i e_t(1-d_i)))\left\{\alpha_i + \sum_{j=1}^{n} \gamma_{ij} \ln \lambda_i p_{it} + \beta_i \ln(e_t / P_t))\right\}.$$

In the case where household characteristics are taken into consideration, the system of equations to be estimated changes to

$$w_{it} = p_{it}(a_i - d_i)S_{it-1} / e_t \tag{42}$$

$$+ (x_t(1-a_i)/(\lambda_i e_t(1-d_i)))\left\{\alpha_i + \sum_{j=1}^{k} d_{ij} z_j + \sum_{j=1}^{n} \gamma_{ij} \ln \lambda_i p_{it} + \beta_i \ln(e_t / P_t))\right\}$$

The estimation for both systems of equations, (41) and (42), is carried out under the following restrictions:

(a) Adding-up: $\sum_i \alpha_i = 1$, $\sum_i \beta_i = 0$, $\sum_i \gamma_{ij} = 1$

(b) Homogeneity: $\sum_j \gamma_{ij} = 1$

[13] The initial value of the stock for the first year of the sample (1987) is computed as the value of the steady-state: $s_{i1987} = q_{i1987} - s_{i1987}$ and, therefore, $s_{i1987} = q_{i1987} / (1 - d_i)$.

(c) Symmetry: $\gamma_{ij} = \gamma_{ji}$

(d) Restrictions that ensure that *z's* (effective quantities) are non negative:

$$\alpha_0 = \ln(e_{\min}),\ \alpha_i \geq 0,\ \alpha_i + \beta_i \ln(e_{\max} / e_{\min}) \geq 0$$

(e) Boundary restrictions that ensure that own price elasticities are negative:

$$\gamma_{ij} \leq (1 - w_i) w_i - \alpha_0 \beta_i^2$$

The system of equations was estimated under several specifications concerning the *a's* and *d's*. Here it is useful to note that the two parameters can capture durability and habit persistence to some degree. In order to make this clearer consider that if we let $d_i = 0$ then $z_{it} = q_{it} - a_i q_{it-1}$, so z_{it} is essentially a stock when $a_i < 0$. So, if one estimates the system restricting $d_i = 0$ and lets a free, then a negative coefficient on the a_i of a good other than durables would indicate that the model is picking up durability of some degree, instead of habituation. The opposite would be true if the specification estimated restricting the *a's* to be zero and let $d's$ free, then a positive d would pick up habituation. The specification chosen to be presented was estimated under the restriction that $d_i = 0$ except for durables and the group of miscellaneous goods and services, since this group contains goods that can be characterized by semi-durability, and $a_i > 0$. The choice to restrict all $d's$ to be zero except for durables can be justified exactly by the fact that, to some extend, both parameters, *a* and *d*, can capture durability and habits. So, including only one of them for goods that we know a priori are not really durable does not cost us in terms of interpretation of results. The other reason for choosing to restrict *d's* is parsimony, which is important with the sample size we have available here.

The parameter estimates for the model without heterogeneity and the diagnostics associated with them are presented in Table 4.1. The estimations rely on the fact that the real rate of interest was assumed to be .02 throughout. The results on habit persistence show considerable habit persistence for non-durables with a habit parameter of 0.391. Durables also show strong habit persistence, although, as Muellbauer and Pashardes (1992) note, in this case it should be more appropriately interpreted as adjustment costs. Miscellaneous goods and services do not exhibit a high habit parameter, but they show high durability. This should, perhaps, be expected since a large part of this group contains commodities that can be characterized by semi-durability, e.g. clothing and footwear. Energy and transport also have a low habit persistence parameter. The results are highly significant for both habit persistence parameters and for durability.

Comparing these estimates with the estimates obtained from the model that accounts for observed heterogeneity[14] in Table 4.2, we see substantial differences. The household heterogeneity characteristics taken into account are the number of children in the household divided in two groups aged 0-4 years and aged 5-18 years respectively, the age of the head and the education of the head in four categories, i.e. a head that completed elementary school, secondary school, comprehensive and tertiary education.[15] The number of children and the age of the head are continuous ones, whereas the education variables are dummies.

Non-durables now have considerably lower habit persistence than before, as do miscellaneous goods and services and energy and transport, although it is not much lower than before for the two latter categories. The durability parameter of miscellaneous goods and services is also somewhat lower then in the previous model. Energy and transport remain with a low habit persistence parameter, slightly lower than in the model with no heterogeneity. All these results point to the direction that when

[14] The full estimation results are presented in Appendix 2.
[15] These are not stated explicitly by individuals in the UK FES Surveys, but they are inferred from the numbers of years reported to have received education.

demographics are included in the dynamic demand model, dynamics measured as habit persistence parameters are not as strong as in the model without demographics. It is as if part of the effect of demographics on consumption for the first three commodity groups is reflected in the habit parameter.

Table 4.1: Estimates of the dynamic AI demand system, no demographics

	Non-durables	Miscella-neous	Fuel, light and transport	Durables
α_i	0.462 (.0005)	0.304 (.003)	0.235 (.005)	0.000 (.000)
β_i	-0.042 (.004)	-0.012 (.002)	-0.015 (.004)	0.069 (.001)
γ_{i1}	-0.105 (.027)	-	-	-
γ_{i2}	0.007 (.021)	0.120 (.032)	-	-
γ_{i3}	-0.028 (.005)	-0.011 (.002)	0.016 (.003)	-
γ_{i4}	0.126 (.022)	-0.116 (.019)	0.023 (.004)	-0.034 (.020)
a_i	0.391 (.031)	0.092 (.016)	0.065 (.013)	0.585 (.186)
d_i	-	.359 (.116)	-	0.519 (.214)
R-square	0.6233	0.8086	0.2057	0.8252
Adj R-square	0.6159	0.8049	0.2032	0.8217
Root MSE	0.0354	0.0179	0.0274	0.0160
Habit effects	$\chi^2 = 190.39$ p-value=0.000			
Durability effects	$\chi^2 = 18.20$ p-value=0.000			
Symmetry	Restricted 803.68 (24)	Unrestricted 658.56 (30)	p-value=0.0001	
Homogeneity	235.04 pvalue=<0.0001	62.2 pvalue=<0.2794	1300.5 pvalue=<0.0001	147.0 pvalue=0.0001

Durability, however, does not seem to be absorbed by the effect of demographics. This is evident from the results on the durability parameter for miscellaneous and the durables. Regarding especially the latter, the results point to the opposite direction since this commodity group now exhibits higher habit and durability estimates. This is not probably surprising, since in the first model without demographics the artificially higher habit persistence parameters on the rest of the three commodity groups resulted in the lower habit and durability estimated for durables.

In both models, habits and durability are quite significant, and the Wald test on these parameters indicates that the hypothesis cannot be rejected. That is, habit persistence and durability play an important part in commodity demand decisions.

Table 4.2: Estimates of the dynamic AI demand system, demographics

	Non-durables	Miscella-neous	Fuel, light and transport	Durables
a_i	0.076 (.022)	0.064 (.130)	0.049 (.014)	0.776 (.728)
d_i	-	.316 (.010)	-	0.782 (.707)
Habit effects	$\chi^2 = 27.30$ p-value=0.000			
Durability effects	$\chi^2 = 10.86$ p-value=0.000			
	Restricted	Unrestricted		
Symmetry	748.64 (56)	633.85 (62)	p-value=0.0001	
Homogeneity	128.12 pvalue=0.0497	71.40 pvalue=0.3818	962.33 pvalue=0.0015	173.25 pvalue=0.0041

The result on the symmetry test[16] in both models is rejected, a result that is in line with empirical work based on static demand models (Blundell et al. (1993)), but comes in contrast to other studies of dynamic demand (Muellbauer and Pashardes (1992), Anderson and Blundell (1992)). The homogeneity hypothesis is tested for every equation of the model separately and the results are also reported in Tables 4.1 and 4.2. The homogeneity test in the model without demographics and other household characteristics is accepted only for the miscellaneous goods and services. In the second model homogeneity cannot be rejected for one additional group, that of non-durables. This is more in line of with other empirical studies based on micro-level data where the homogeneity condition is hardly ever rejected (Blundell et al. 1993).

Elasticities

The elasticities are reported in Tables 4.3 and 4.4. In a dynamic context there are two elasticity notions that we can estimate, the instant (or short run) and the long run. We present here only the instant, uncompensated (or Marchallian) price elasticities. All own price elasticities are negative, and point to the direction that would be expected, although sometimes they are a bit higher than expected, and this applies especially to non-durables.

[16] This test is carried out by imposing the covariance of the unrestricted residuals on the restricted estimates and computing the difference in the log-likelihood function between the restricted and unrestricted estimates (Gallant (1987)).

Muellbauer and Pashardes (1992) who used aggregate data failed to find a negative own price elasticity of food. A negative cross price elasticity indicates that the goods are complements, whereas a positive one indicates that they are substitutes.

Table 4. 3: Price and budget elasticities, no demographics

	Non-durables	Misc-ellaneous	Energy and transport	Durables	Budget elasticities
Non-durables	-0.736	0.039	-0.012	0.216	0.546
	(.058)	(.031)	(.007)	(.039)	(.026)
Miscellaneous	0.052	-2.346	-0.039	-0.570	1.357
	(.063)	(.210)	(.012)	(.119)	(.021)
Energy and transport	-0.102	-0.033	-0.853	0.114	0.870
	(.022)	(.010)	(.017)	(.016)	(.019)
Durables	1.126	-1.030	0.206	-1.166	1.528
	(.202)	(.182)	(.033)	(.171)	(.045)

The elasticity estimates when demographics are taken into account are in most cases higher, as shown in Table 4.4. Non-durables and miscellaneous goods and services appear to be substitutes in the model without demographics and complements in the model with heterogeneity.

Table 4. 4: Price and budget elasticities, demographics

	Non-durables	Misc-ellaneous	Energy and transport	Durables	Budget elasticities
Non-durables	-1.042	0.107	0.089	0.553	0.693
	(.055)	(.052)	(.028)	(.050)	(.028)
Miscellaneous	-0.107	-1.845	-0.031	-0.824	1.334
	(.096)	(.207)	(.009)	(.115)	(.043)
Energy and transport	-0.154	-0.055	-0.877	0.043	1.085
	(.022)	(.010)	(.016)	(.015)	(.042)
Durables	2.052	-1.971	0.178	-1.289	1.930
	(.218)	(.242)	(.039)	(.134)	(.064)

The budget elasticities also change for the case of energy and transport, where now they appear as a luxury instead of a necessity.

4. CONCLUSIONS

This paper has estimated a dynamic demand system of commodity demands using synthetic cohort data created from a sample of the UK Family Expenditure Survey covering the period 1987-2001. The model used is the dynamic demand system developed by Muellbauer and Pashardes (1992), based on the Almost Ideal demand system. Dynamics in the system are introduced through durability and habit formation by substituting quantities with effective quantities which form a linear transformation of actual quantities. Durability and habit persistence are expressed by two different parameters which allow distinguishing empirically between the two. However, one can include either of the two parameters in the model, in which case the sign of the parameter indicates durability and habit persistence, as in many other studies of these issues (Pashardes (1986)). The model is estimated two times, once ignoring any household heterogeneity and another by taking heterogeneity into account by adding into the system demographic variables expressed as number of children divided in two age groups, 0-4 and 5-18, the number of other adults in the household apart from the head, the age of the head and the education of the head.

The model is estimated for four commodity groups, namely non-durables (food and alcohol), miscellaneous goods and services (clothing and footwear, household goods and services, leisure goods and services etc), energy and transport and durables (vehicles, electrical goods, furniture and furnishings). The results for the model without heterogeneity indicate that consumption shows considerable habit persistence for non-durables which is a commodity group comprising of food, alcohol and tobacco, and durables. Miscellaneous goods and services and energy and transport exhibit much lower habit persistence. Miscellaneous goods and services were also modeled having a durability parameter as this is a group containing to a large part semi-durable goods such as clothing and footwear. Indeed the durability parameter of this group is substantial and significant.

These results are reversed when demographics is taken into account. Non-durables show much lower habit persistence. Miscellaneous goods and services and energy and transport have even lower habit persistence coefficients, but the durability parameter for the miscellaneous group does not change significantly. Durables on the other hand, show higher habit persistence and durability in the heterogeneity model than in the non-heterogeneity model.

The results of this model come to agree with studies than find evidence of habit formation even when heterogeneity is taken into account. However, the heterogeneity variables considered in this paper ignore the employment and participation status of the adults of the household. This could lead to biased results for other demographic variables included in the model. In particular, female employment is known to be highly correlated with the presence of young children (Mroz (1987)). If there are children in the household the woman is less likely to be employed. Therefore, by ignoring female employment the effect of child presence in the allocation of expenditure to commodity groups could actually be representing employment effects. For example, transport costs would be lower if a woman decides to stop working and have a child.

If the model was estimated restricting the sample to couples with or without children with a working male head, the analysis could incorporate employment heterogeneity variables that would require instrumenting since employment is correlated to total expenditure in the demand equations. Instead of complicating the model in this way, the framework of dynamic demand system could incorporate labour supply, or leisure, in a direct way by including leisure as another item in the utility that the consumer maximizes. It complicates the analysis somewhat because one has to model labour supply properly to some degree, but it also has the advantage that it can provide explicit price elasticity estimates for leisure.

Finally, since the dynamic demand system estimation is already a computationally costly process, the number of observations would have to be substantially higher to accommodate such an analysis, so a true panel should perhaps be used. The results, though, of the simple commodity demand model assuming separability from leisure indicate that it is a valuable instrument in studying leisure for a number of issues, and especially concerning the tax and benefit system that have an impact on prices and incomes. The next chapter presents such a model in the simplest possible application.

REFERENCES

Alessie R, Kapteyn A (1991), "Habit formation, interdependent preferences and demographic effects in the almost ideal demand system", *Economic Journal*, 101, pp404-419

Anderson G, Blundell R (1982), "Estimation and hypothesis testing in dynamic singular equations systems", *Econometrica*, 50, 1559-1571

Attanasio O.P, Weber G (1995), "Is Consumption Growth Consistent with Intertemporal Optimization? Evidence from the Consumer Expenditure Survey", *Journal of Political Economy*, 103, 1121-1157

Bernstein J, Mamuneas T.P., Pashardes P. (1999), "Factor Adjustment, Quality Change and Productivity Growth for U.S. Manufacturing", NBER Working Paper 6877

Browning M (1991), "A simple non-additive preference structure for models of household behavior over time", *Journal of Political Economy*, 99, 607-637

Browning M, Collado M.D. (2001), "The Response of Expenditures to Anticipated Income Changes: Panel Data Estimates", *American Economic Review*, 91, 681-692

Browning M, Meghir C (1991), "The Effects of Male and Female Labour Supply on Commodity Demands", *Econometrica*, 59, 925-951

Blundell R., Pashardes P, Weber G (1993), "What Do We Learn About Consumer Demand Patterns from Micro Data", *American Economic Review*, 83, 570-597.

Carasco R., Labeaga J.M., Lopez-Salido J.D., (2005), "Consumption and Habits: Evidence from Panel Data", *The Economic Journal*, 115, 144-165.

Constantinides G.M. (1990), "Habit Formation: A Resolution of the Equity Premium Puzzle", *Journal of Political Economy*, 98, 519-543

Deaton A (1985), "Panel data from time series of cross sections", *Journal of Econometrics*, 30, 109-126.

Deaton A, Muellbauer J (1980), "An Almost Ideal Demand System", *American Economic Review*, 70, 312-326

Deaton A, Muellbauer J (1980), *Economics and Consumer Behavior*, Cambridge: Cambridge University Press

Dynan K (2000), "Habit Formation in Consumer Preferences", *American Economic Review*, 90, 391-406

Gallant A.R. (1987), *Non-linear statistical models*, John Wiley and Sons.

Gorman W (1967), "Tastes, Habits and Choices", *International Economic Review*, 8, 218-222

Houthakker H.S., Taylor L (1966, 1970 2nd ed.), *Consumer Demand in the United States 1929-70, Analysis and Projections*, Cambridge, Mass.; Harvard University Press

Lluch C. (1974), "Expenditure , savings and habit formation", *International Economic Review*, 15, 768-797.

Meghir C, Weber G (1996), "Intertemporal Non-Separability or Borrowing Restrictions? A Disaggregate Analysis Using a U.S. Consumption Panel", *Econometrica*, 64, 1151-82.

Mroz TA (1987), "The Sensitivity of an Empirical Model of Married Women's hours of work to Economic and Statistical assumptions", *Econometrica*, 55, 765-799.

Muellbauer J, Pashardes P (1982, 1992), "Tests of dynamic specification and homogeneity in a demand system", Birkbeck College Discussion Paper No. 125; revision published in Phlips L and Taylor LD (ed.) *Aggregation, Consumption and Trade: Essays in Honour of Hendrick Houthakker*, Kluwer Academic Publishers, 55-98.

Naik N.Y., Moore M.J. (1996), "Habit Formation and Intertemporal Substitution in Individual Food Consumption", *The Review of Economics and Statistics*, 78, 321-328

Pashardes P (1986), "Myopic and forward looking behaviour in a dynamic demand system", *International Economic Review*, 27, 387-398

Phlips L (1972), " A dynamic version of the linear expenditure model", *Review of Economics and Statistics*, 54, 450-458

Phlips L (1974), Applied consumption analysis (North-Holland, Amsterdam)

Phlips L, Spinnewyn F (1982), "Rationality versus myopia in dynamic demand systems", *Advances in Econometrics*, 1, 3-33, JAI Press

Pollak R. A. (1970), "Habit formation and dynamic demand functions", *Journal of Political economy*, 78, 745-753

Pollak R. A. (1976), "Habit formation and long run utility functions", *Journal of Political Economy*, 13, 292-297

Pollak R. A. (1978),"Endogenous tastes in demand and welfare analysis", *American Economic Review*, 78, 374-379

Pollak R. A., Wales R. (1969), "Estimation of the linear expenditure system", *Econometrica*, 3, 1-48

Spinnewyn F (1979), "The cost of consumption and wealth in a model of habit formation", *Economic Letters*, 2, 145-148

Spinnewyn F (1981), "Rational Habit formation", *European Economic Review*, 15, 91-109

Stoker T (1986), "Simple tests of distributional effects on macroeconomic equations", *Journal of Political Economy*, 94, 763-95

Taylor L, Weiserbs D (1972), "On the estimation of dynamic demand functions", *Review of Economics and Statistics*, 54, 459-465

Weissenberger E (1986), "An intertemporal system of dynamic consumer demand functions", *European Economic Review*, 30, 859-891

APPENDIX 1

Figures A.1 to A.4 show the consumption pattern of the budget share of the four expenditure groups, plotted against the age of the head of the household. As Figure A.1 shows, consumption on non durables (food, alcohol and tobacco) increases with age, i.e. older cohorts have a higher share of non durables as would be expected with a group of goods that are characterized as necessities.

Miscellaneous goods and services also show a slight hump for younger cohorts. Energy and Transport budget share increases with age, and, finally, the budget share of durables is higher for younger cohorts.

Figure A.1: Budget share of non durables

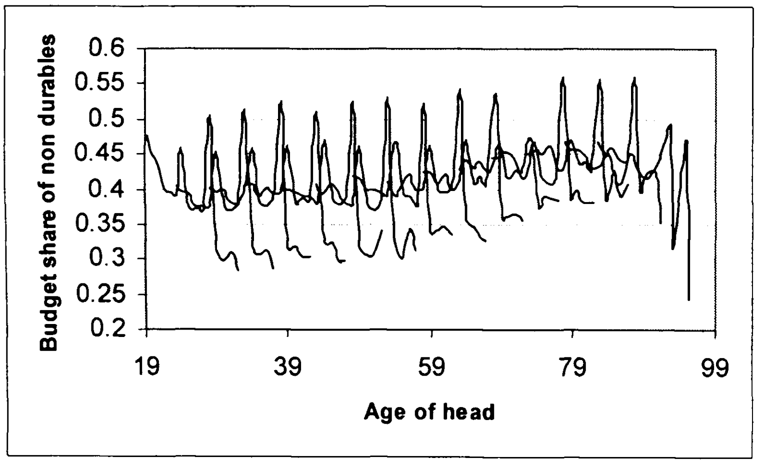


Figure A.2: Budget share of miscellaneous goods and services

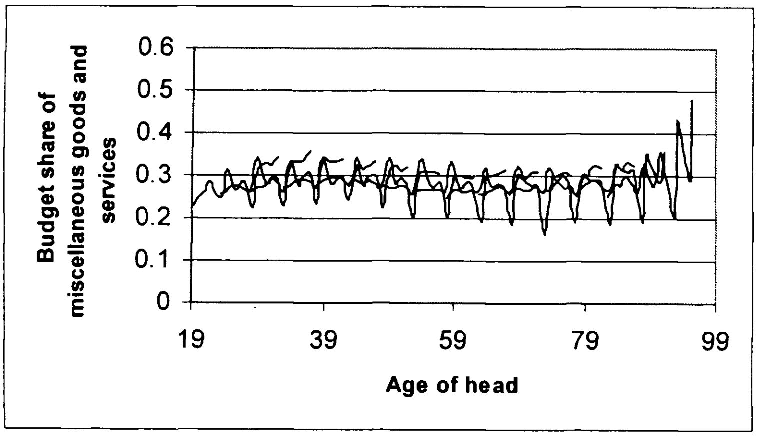


Figure 3: Budget share of energy and transport

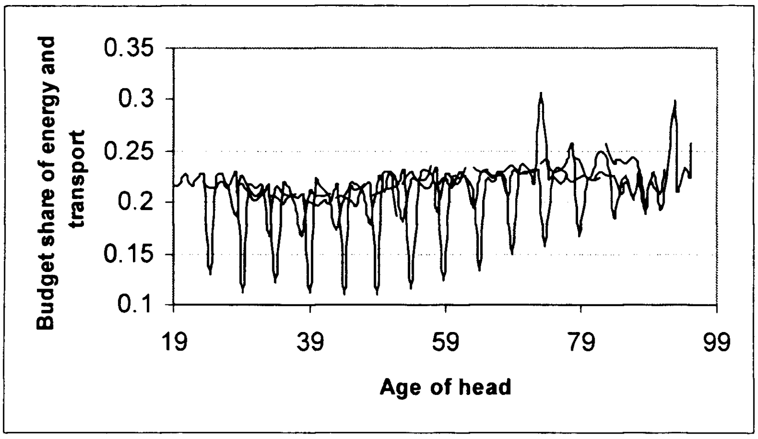
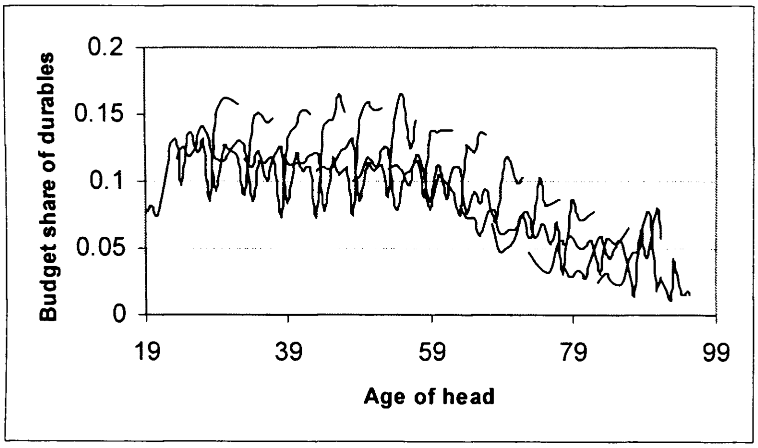


Figure 4: Budget share of durables



APPENDIX 2

Estimation results of the heterogeneity model

Table A.1: Estimates of the dynamic AI demand system, heterogeneity

	Non-durables	Miscella-neous	Fuel, light and transport	Durables
α_i	0.6824	0.1462	0.1714	0.0000
	0.0352	0.0187	0.0335	0.0000
β_i	-0.1026	-0.0072	0.0312	0.0787
	0.0104	0.0055	0.0091	0.0042
γ_{i1}	-0.1221	-	-	-
	0.0228			
γ_{i2}	-0.0228	0.0198	-	-
	0.0198	0.0312		
γ_{i3}	-0.0304	-0.0073	0.0224	-
	0.0047	0.0019	0.0029	
γ_{i4}	0.1752	-0.1683	0.0152	-0.0122
	0.0172	0.0175	0.0033	0.0122
a_i	0.0756	0.0639	0.0494	0.7756
	0.0219	0.1298	0.0137	0.7278
d_i	-	0.3156	-	0.7822
		0.0992		0.7067
child age 0-5	-0.2206	0.0700	0.0277	0.0531
	0.0326	0.0149	0.0294	0.0105
child age 5-18	-0.0040	0.0208	-0.0128	-0.0171
	0.0078	0.0031	0.0064	0.0034
age of the head	-0.0029	0.0012	0.0001	-0.0002
	0.0004	0.0002	0.0003	0.0000
head: education				
elementary	0.0057	-0.1179	0.0448	0.1231
	0.1553	0.0575	0.1272	0.0660
secondary	-0.0125	0.0150	-0.0192	-0.0232
	0.0222	0.0086	0.0182	0.0094
comprehensive	-0.8988	0.1951	0.1189	0.0123
	0.3148	0.1186	0.2618	0.1317
tertiary	0.2458	0.0988	-0.4499	-0.2072
	0.1308	0.0487	0.1055	0.0578
Other adults in the household	-0.0330	0.0383	-0.0294	-0.0087
	0.0278	0.0109	0.0230	0.0126
R-square	0.7237	0.8318	0.2633	0.8776
Adj R- square	0.7068	0.8215	0.2182	0.8701
Root MSE	0.0309	0.0162	0.0247	0.0137

CHAPTER 3

COMMODITY DEMANDS AND LABOUR SUPPLY: A JOINT ESTIMATION IN A DYNAMIC ALMOST IDEAL DEMAND SYSTEM

ABSTRACT. In this paper, commodity demands and labour supply are investigated jointly in a dynamic context. The proposed model is applied to the UK Family Expenditure Survey data over the period 1987-2001 using average cohort techniques. A dynamic Almost Ideal demand system is estimated for four commodity groups along with male leisure and female leisure to find that female leisure shows habit persistence, in contrast to male leisure. Habit persistence is also evident for two of the commodity groups. Separability is strongly rejected and the elasticities which are implied by habit persistence and durability are also investigated.

1. INTRODUCTION

In empirically investigating demand and consumption one has to decide on how to treat intertemporal and intratemporal separability. To assume intertemporal separability is very convenient, and the simplicity it adds to the analysis and model specification is the reason why it is much favoured in the literature. The same of course holds with the assumption of intratemporal separability. The two assumptions are widely accepted to be unrealistic ones and have been relaxed in much of the existing empirical work.

Part of the existing literature, and particularly the early work, treats the two assumptions separately because of the use of aggregate data. The work on intertemporal separability revolves around two of the most important cases when intertemporal separability is violated, i.e. durable goods and habit formation. The time dependence of preferences implied by durability and habit formation is one of the things that complicated discussion.

The literature on habit formation and durability and the dynamic properties they implicate for demand systems goes back more than three decades The early work introduced habit formation and durability in a myopic framework (Houthakker and Taylor (1966, 1970), Pollak and Wales (1969), Taylor and Weiserbs (1972), Phlips (1972), Gorman (1967), Pollak (1970, 1976, 1978)). Consumers recognize that current consumption depends on past consumption, and thus on past habits, but does not take into account the effect of current consumption on future preferences. Rational habit formation, on the contrary, does take the latter effect into account and such models were developed by Lluch (1974) and Phlips (1974). However, Spinneweyn (1981) was the first to present a simplified approach by acknowledging that a redefinition of the cost of consumption and wealth (user cost concepts) makes a model with rational habit formation equivalent to a model with no habit formation. Later, Phlips and Spinneweyn (1982) showed that, under certain assumptions on expectations and preferences, myopic and rational habit formation are equivalent.

Muellbauer and Pashardes (1992) propose a model which incorporates durability and habits in the utility function that is parsimonious in parameters and estimate both the static and dynamic version of the AI demand system to fund that homogeneity and symmetry are acceptable in the dynamic form.

One particular important thing to note is that although the literature on durability and habits is a rich one, little is based on microeconomic data, and the reason is that very few panel data contain information on consumption. Some recent notable exceptions are the papers by Meghir and Weber (1996), Naik and Moore (1996), Dynan (2000) and Carasco et al (2005). Meghir and Weber (1996) use data from the Consumption Expenditure Survey (CEX) of the US that contains information on the consumption of the same households for four consecutive quarters since it is a rotating panel. They estimate the within-period marginal rate of substitution which is robust to the presence of liquidity constraints and do not find evidence of habit formation. Naik and Moore (1996) and Dynan (2000) use yearly information from the Panel Study of Income Dynamics (PSID) of the US where there is information only on food consumption. The two papers reach the opposite conclusions as the first finds evidence of habit formation but the second does not. Carasco et al (2005) argue that the results of all three papers have drawbacks arising partly from their use of data. They follow the estimation method proposed by Meghir and Weber (1996) and use it with a Spanish panel data set with eight consecutive quarters of available information, in contrast to the four available in the CEX, and find evidence of habit formation in the demand system of food at home, transport and services.

The second strand of literature has to do with modelling labour supply jointly with consumption. Whether a person works or not may affect the amount he/she consumes of certain commodities like transport, heating or child care. Ignoring the relevance of this and modelling commodity demands and leisure separately will lead to biased results if there is any correlation between the wage rate that is left out and the price, expenditure or demographics that are included in the demand system. There are two approaches one could take, the unconditional and the conditional one. The latter approach has, perhaps the biggest, advantage that the researcher is not bothered with modelling properly labour supply. Also, if an appropriate specification is taken, separability of labour supply from consumption can be brought down to a simple test of the statistical significance of the parameters of the equation relating to labour supply and/or participation. A disadvantage, though, is that one cannot estimate labour supply elasticities. However, these elasticities will enter the price elasticity of a good if one assumes that labour supply is not exogenous.

In part, the approach of Meghir and Weber (1996), and other similar papers, belong in this context as they try to identify the effect of household heterogeneity on the evidence on the time dependence of commodity demands. One of the most important factors of heterogeneity examined is that of labour supply and participation. However, labour supply and commodity demands have not been modelled jointly in an unconditional dynamic demand system framework. This is what is attempted in this paper.

Browning and Meghir (1991) in a very influential paper use the conditional approach that is an extention of Pollak's (1969, 1971) conditional demand approach. They estimate an AI demand system for a number of goods and services, taken from the UK Family Expenditure Surveys from 1979 through 1984. Their specifications contain male and female hours worked for households composed by married adults, under official retirement age, with or without children. They also include participation dummies for both partners. They let these variables to affect both the intercept of the budget share equations and the total expenditure coefficients. They conclude that separability is rejected. Blundell and Walker (1982) model commodity demands and labour supply, treating hours worked as an unconditional variable. Thus, male and female hours worked are estimated as two additional commodities in a Linear Expenditure System (LES) demand system. Taking into consideration that male hours may be rationed, i.e. not freely chosen but predetermined, they estimate both an unrationed and rationed model. Since their sample consists of married couples where the heads are male manual workers, they control for nonparticipation of females using a technique developed by Amemiya (1974) and Heckman (1979). They reject separability for both of the models estimated.

This paper uses data from the UK Family Expenditure Surveys from 1987 to 2001 and estimates a dynamic Almost Ideal Demand System. The framework of analysis adopted is that of Muellbauer and Pashardes (1992), taking it a bit further by including leisure in the model and introducing an expectation generating process for commodity and leisure prices, a technique due to Bernstein et al (1999). The aim is to test separability between commodity demands and labour supply in a dynamic context and to examine the effect on habit and durability estimated coefficients from the inclusion of leisure in the demand system. The analysis is based on average cohort techniques constructed from the age of the head of the household. This has some implications on the dynamic analysis performed and the results should be interpreted accordingly. However, it is useful to note here that although panel data would be the appropriate ones to use in dynamic analysis, it is a fact that a good panel dataset with an adequate length of time periods is not available as yet. The use of quarterly data of a length of four or eight consecutive quarters of individual data does not provide an adequate time span for dynamic analysis for the estimation of habit and durability effects. In contrast, there is a wealth of good quality cross-sectional data available for large periods of time, and one of these datasets, the UK FES is used in this study.

Section 2 describes the model and derives the formulas for estimating the price and expenditure elasticities. Section 3 describes the data and presents some descriptive statistics. A special mention is made for the implications of using cohort data and what this means for the interpretation of results relating to durability and habit formation. Section 4 presents the empirical specification and the estimation results. Finally, Section 5 concludes.

2. MODEL SPECIFICATION

The standard way to derive a demand system is by assuming each consumer has the following intertemporal utility function:

$$U = U(q_{1t},\ldots,q_{nt},\ldots,q_{1T},\ldots,q_{nT}) \tag{1}$$

The corresponding life-cycle budget constraint is

$$W_t = \sum_{i=1}^{n}\sum_{j=t}^{T} \hat{p}_{ij} q_{ij}\ , \tag{2}$$

where $\hat{p}_{ij}$ is the discounted price for good i in period j expected at time t.

Such a utility function lies behind every static demand system and, with the assumption of weak separability, two-stage budgeting is possible and the consumer allocates expenditures e_t across periods and then maximizes

$$u = v(q_{1t}, q_{2t}, \ldots, q_{nt}),\tag{3}$$

in each period of life subject to the budget constraint

$$\sum_{i=1}^{n} p_{it} q_{it} = e_t,\tag{4}$$

where e_t is total expenditure at time t.

In Muellbauer and Pashardes (1992) durability is introduced by defining the stock of good i in period t as

$$S_{ij} = q_{ij} + d_i S_{ij-1},\tag{5}$$

where in each period the consumer adds quantity q of good i to a proportion d of the stock remaining from last period. If the consumer develops habits then consumption in each period must be higher than last period's consumption, in order for consumption to contribute the same to utility. This is expressed by a variable z_{ij} which should replace q_{ij} as follows:

$$z_{ij} = S_{ij} - a_i S_{ij-1}\tag{6}$$

where $0 \le a_i < 1$ and which can be expressed as a function of q_{ij} if we replace (5) in place of S_{ij}.

In essence, the consumer minimizes the life-time budget constraint (2), s.t. (1), (5) and (6). The life time budget constraint can be written explicitly by defining a discounting factor:

$$\sum_{j=0}^{\infty}\sum_{i=1}^{n}(1/(1+r_{t+j}))^{j}p_{it+j}^{e}q_{it+j} \tag{7}$$

where one more issue is introduced, that of price expectations, expressed by p_{it+j}^{e}, which is the expected price of good *i* at time *t+i* expected at time *t*. We will specify the price expectations generating process in Section 4.

The Lagrangian associated with (7) under the restrictions (1), (5) and (6) is:

$$L=\sum_{j=0}^{\infty}(1+r_{t+j})^{-j}\{\sum_{i=1}^{n}p_{it+j}^{e}\left(S_{it+j}-d_{i}S_{it+j-1}\right)$$

$$-\lambda_{t+j}[U(S_{1t+j}-a_{1}S_{1t+j-1},\ldots,S_{nt+j}-a_{n}S_{nt+j-1})-U_{t+j}\} \tag{8}$$

where λ_{t+j} is the Lagrangian multiplier in period *t+j*.

The first order condition derived from (8), solving for the S_{ij}'s, is:

$$L=(1/(1+r_{t+j}))^{j}p_{it+j}^{e}-(1/(1+r_{t+j}))^{j}\lambda_{t+j}\frac{\partial U}{\partial z_{it+j}}-(1/(1+r_{t+j+1}))^{j+1}p_{it+j+1}^{e}d_{i}$$

$$+(1/(1+r_{t+j+1}))^{j+1}\lambda_{t+j+1}a_{i}\frac{\partial U}{\partial z_{it+j+1}}=0,\ i=1,2,\ldots,n \tag{9}$$

Dividing (9) by $(1/(1+r_{t+j}))^j$ and by assuming that the real discount rate[17] is constant we get the following expression for the Euler equation:

$$\lambda_{t+j} \partial U / \partial z_{it+j} = p'^{e}_{it+j} + (1/(1+r_{t+j+1}))a_i \lambda_{t+j+1} \partial U / \partial z_{it+j+1} \tag{10}$$

where $p'^{e}_{it+j} = p^{e}_{it+j} - (d_i/(1+r_{t+j+1}))p^{e}_{it+j+1}$. (11)

Equation can be evaluated for a finite period, i.e. for values of j from 0 to T, and the system can then be solved recursively and it is easy to show that:

$$\lambda_t U_{z_{it}} = \sum_{j=0}^{T} p'^{e}_{it+j}(a_i)^j + (a_i / 1+r)^{T+1} \lambda_{t+T+1} U_{z_{it+T+1}} \tag{12}$$

If we let $T \to \infty$ Equation (12) reduces to

$$\lambda_t U_{z_{it}} = \sum_{j=0}^{\infty} p'^{e}_{it+j}(a_i/(1+r))^j \tag{13}$$

[18]

At this point we introduce price expectations. The most common assumption in empirical work (and theoretical work concerning the dynamic version demand systems) is that price expectations are constant. In other words consumers expect relative prices to remain the same in all periods. A more realistic assumption that complicates the analysis albeit in a minor way is that prices follow an AR(1) process

[17] This is a common assumption in dynamic analysis

[18] This makes use of the transversality condition which states that the shadow value of the marginal utility goes to zero as T goes to infinity.

$$p_{it+1} = \xi_i + \rho_i p_{it} + \eta_{it+1}, \forall i, \qquad i=1,\ldots,n \tag{14}$$

where η_{it+1} an i.i.d. error term with zero mean. Equation (14) implies that the expectation at time t of the price prevailing at time *t+j*

$$p^e_{it+j} = \xi_i(1-\rho_i^{\,j})\Big/(1-\rho_i) + \rho_i^{\,j} p_{it} \tag{15}$$

Using (14) and (15) in solution (13) will give us the expression we seek, namely the expression that relates p'_{it} to p_{it}. Some brief algebra leads to the following expression[19]

$$p'_{it} = p_{it}\left(1-(d_i\rho_i/(1+r)\Big/1-(a_i\rho_i/(1+r)\right) + f(\xi_i,\rho_i,a_i,d_i,r) \tag{16}$$

where

$$f(\xi_i,\rho_i,a_i,d_i,r) = (\xi_i/(1-\rho_i))[(1-(d_i/(1+r))/(1-(a_i/(1+r))$$

$$- (1-(d_i\rho_i/(1+r))/(1-(a_i\rho_i/(1+r))]$$

In the case when expectations are taken to be constant, (16) reduces to

$$p'_{it} = p_{it}((1+r-d_i)/(1+r-a_i)) \tag{17}$$

which is exactly the one used in the Muellbauer and Pashardes (1992) paper.

[19] For the exact derivation see Bernstein et al (1999).

The above solution derived from expressing the problem as an Euler equation as was done in the exposition above is the same with that taken from minimizing the budget constraint facing the consumer in a given period $\sum_i p'_{it} z_{it}$, subject to the utility function expressed using effective quantities $u = u(z_{it},...z_{nt})$.[20] Duality specifies that minimization of the budget constraint equals the maximization of utility subject to the budget constraint. This is the procedure followed by Muellbauer and Pashardes (1992) which will be replicated here, adding leisure into the analysis.

Adding Leisure in the system

Households, in addition to deciding the allocation of expenditure across goods and services, also decide how to allocate available time, time endowment T, between work and leisure. The joint modelling of leisure and commodity demands gives the ability to test whether the two are indeed separable at any given time. Also, testing the importance of cross-price elasticities is of particular interest and this can only be done if leisure is considered as an additional 'good' in the model, and that means to follow the unconditional modelling approach, instead of just as a conditioning variable on the right-hand side of an equation. Our approach follows that of Deaton and Muellbauer (1980), which was also used in other studies of this kind (Blundell and Walker (1982) for an example using the LES demand

[20] This was explicitly shown in Chapter 2, p.42.

system) and apply it on the AI demand system as will be specified in Section 4. The problem the consumer has to solve is given by

$$Max\ u(z_{it}, z_{2t}, \ldots, z_{nt}, l'_t) \tag{18}$$

$$s.t.\ p'z + w'l' = w'T + \hat{\mu} = \mu'$$

As seen above, the big difference from introducing leisure in the model comes through the budget constraint where μ' is commonly termed as full income, $z = (z_1, \ldots, z_n)$ is a vector of n effective quantities of goods and services, $p' = (p'_1, \ldots, p'_n)$ is the vector of corresponding adjusted prices, w' is the adjusted wage rate (used for the marginal value of leisure), adjusted in same way as prices, and T is total time available for any individual for work and leisure, after allowing for other necessary activities e.g. for sleep. The marginal value of leisure, the wage rate, enters the budget constraint in two ways. The first is the conventional way like any other normal price of any other commodity, and the second is by valuing time endowment T on the right-hand side of the budget constraint.

Leisure in the utility function is treated like any other commodity, and l' indicates effective leisure that takes place after considering durability and habits. Of course, as will be clearer later on in Section 4, leisure is not assumed to be characterized by durability, but only by habit formation.

Individuals that participate in the labour market at a given time may be more likely to participate in the future because they form a habit that could arise because of family obligations or a certain lifestyle pattern (some individuals tend to be career orientated and some are not).

Solving (18) gives the Marshallian (uncompensated) demand functions

$$z_{it} = g_i(p_t', w_t', \mu) \tag{19}$$

and leisure demand is expressed in a similar fashion

$$l_t' = g_l(p_t', w_t', \mu) \tag{20}$$

Since $z's$ and l' are not observable, equations (19) and (20) are expressed in terms of the observables $q's$ and l as it is done below

$$q_{it} = g_i(p_t', w_t', \mu) + (a_i - d_i)S_{it-1} \tag{21}$$

$$l_t = g_l(p_t', w_t', \mu) + (a_i - d_i)S_{lt-1} \tag{22}$$

3. THE DATA

The sample of the data is drawn from the UK Family Expenditure Survey for the years 1987 to 2001 comprising of 104314 households. Households consisting of married working couples with or without children are considered only. This means that the only adults present in the household are the male head and the female spouse working as employees. In two adult households one has to model the leisure of the head and the leisure of the spouse, essentially including in the demand system two additional share equations. This is a major simplification of the analysis and it is a procedure commonly used in empirical work.

Table 3.1: Summary statistics

Variable Type	Mean	Std. Dev	Min	Max
Consumption:				
Non durables	81,19	15,62	41,80	117,10
Miscellaneous	72,84	20,45	9,06	120,67
Fuel, light and transport	85,96	71,34	23,70	350,66
Durables	41,86	17,35	6,08	93,38
Expenditure Shares				
Non durables	0,25	0,04	0,18	0,32
Miscellaneous	0,19	0,03	0,07	0,24
Fuel, light and transport	0,13	0,02	0,06	0,20
Durables	0,09	0,02	0,04	0,13
Labour Supply				
Leisure:				
Men	39,53	1,24	36,69	44,04
Women	52,43	2,51	41,33	57,58
Expenditure Shares				
Men	0,14	0,02	0,12	0,20
Women	0,19	0,03	0,15	0,33
Wages:				
Men	355,48	86,40	109,25	524,52
Women	170,00	43,41	73,98	263,44

Since the UK FES is not a panel, synthetic cohort technique is applied by creating 5-year birth cohorts[21] according to the age of the head of the

[21] Given than the average wage is used as the price (opportunity cost) of leisure it would prove useful to spit the cohorts by education groups since the model attempts to explain

household following the same procedure as in Chapter 2 (Table 3.1). Households consisting of heads above statutory retirement age are excluded from the estimation as are households with female spouses above statutory retirement age. The restricted sample shrinks to 19439 households. The biggest reduction in the sample is primarily caused by the choice of men and women under statutory retirement age, and secondary by the choice of married couples where the head is an employee. Table 3.1 provides summary statistics of the sample used.

Expenditure is divided in four broad categories for the sake of parsimony which is considered to be essential due to the small number of observations finally used for the estimations:

(e) Non-durables: food and catering, alcohol and tobacco

(f) Miscellaneous goods and services: clothing and footwear, leisure goods and services, household goods and services

(g) Energy and Transport

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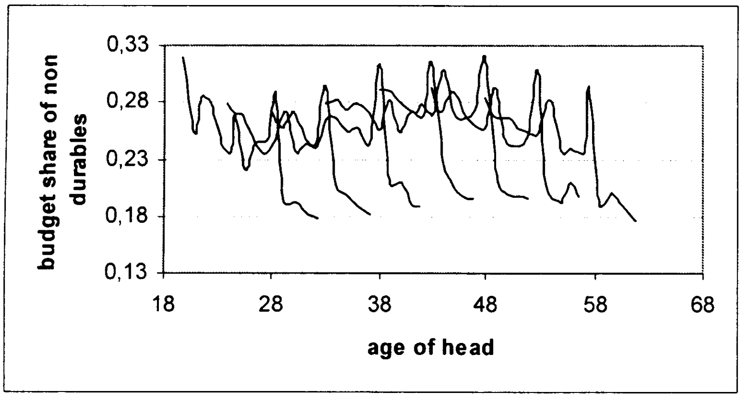
dynamics in the choice of hours of work. This is because the evolution of wages, both for men and women, is expected to have been very different across cohorts and across education groups. This is not attempted in this paper because the sub-samples that would be obtained would be too small for the computationally costly estimation of the dynamic demand system.

(h) Durables: include vehicles, electrical goods and furniture.

Housing, health, education and holiday expenditure are excluded from the analysis, and hence the analysis is conducted under the assumption that consumption is separable from these goods. These commodity groups, along with male leisure and female leisure form the six budget share equations to be estimated.

Figures 3.1 to 3.4 show the consumption pattern of the budget share of the four expenditure groups, plotted against the age of the head of the household. As Figure 1 shows, consumption on non durables (food, alcohol and tobacco) exhibits a hump for households with heads in their 30's and 40's which then declines.

Figure 3.1: Budget share of non durables



Miscellaneous goods and services also show a hump, i.e. they increase with the age of the head and start declining after 50 years of age. Energy and

Figure 3.2: Budget share of miscellaneous goods and services

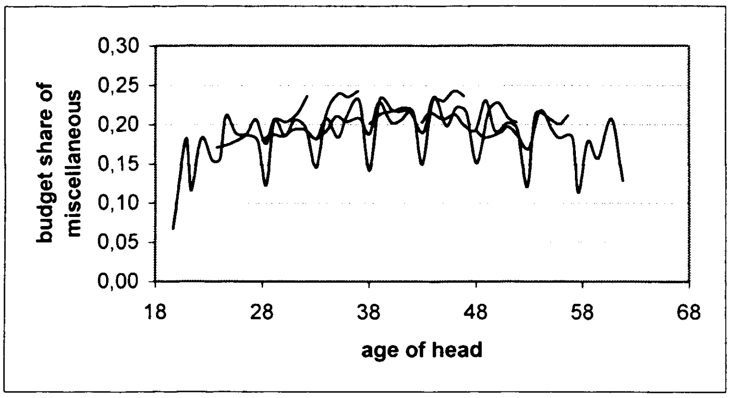


Figure 3.3: Budget share of energy and transport

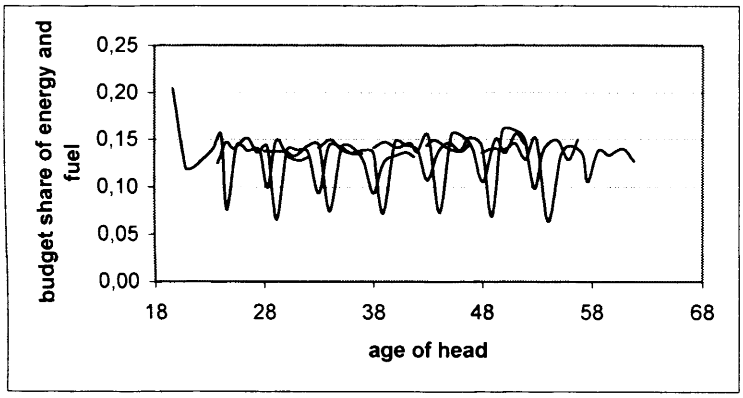
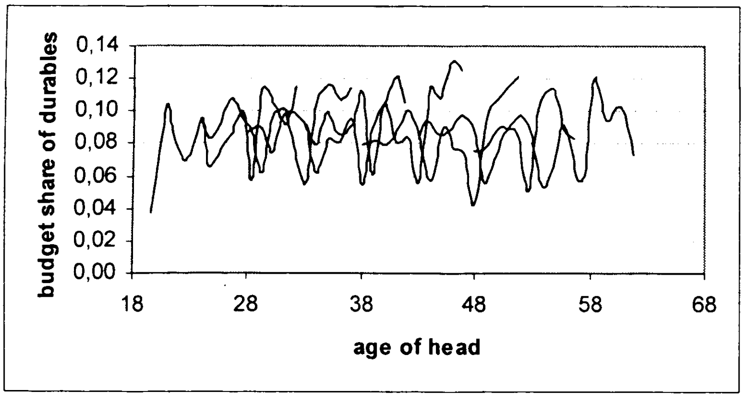


Figure 3.4: Budget share of durables



Transport does not show evidence of a hump, and, finally, the budget share of durables increases with age.

The next two diagrams show the budget share of leisure for the male head and the female spouse respectively. Weekly leisure is used in the estimation and is calculated by subtracting hours work from weekly time endowment T[22]. The budget share of the male head leisure is graphed against the age of the head in Figure 3.5. It appears that men decrease their share of leisure in their mid 30's through to their 40's. Male leisure starts increasing again in the early 50's.

Figure 3.5: Budget share of male leisure

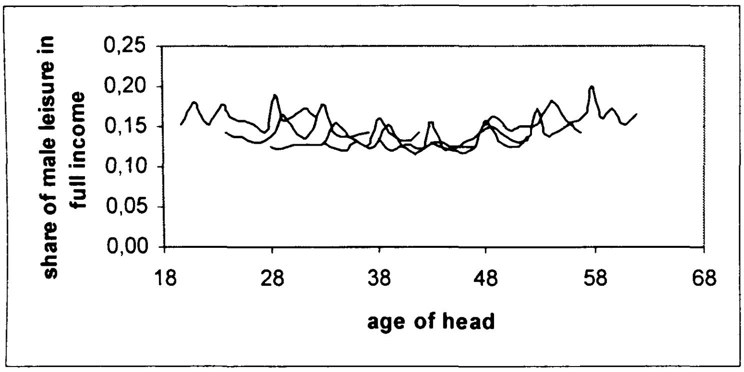
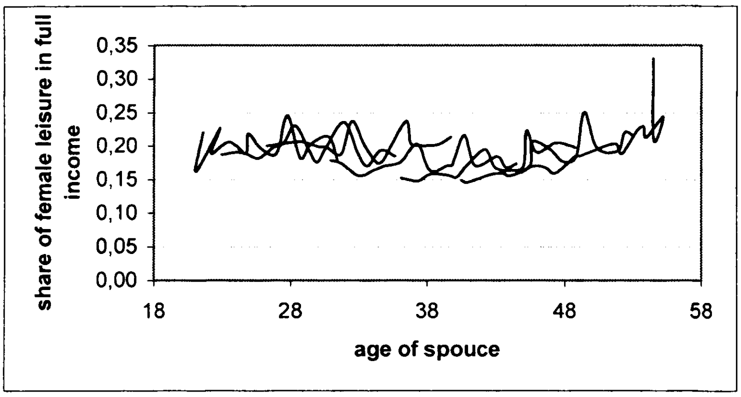


Figure 3.6 graphs the budget share of female leisure against the age of the spouse. The share of leisure is high in the early years and then declines in the early 30's to start rising again in the early 50's.

[22] Weekly time endowment T is calculated as: T=(24-8)*5-weekly hours worked, assuming a five-day working week and eight hours allocated to sleep.

Figure 3.6: Budget share of female leisure



Finally, the wage rate measure used is the normal gross weekly earnings of the male head and the female spouse respectively. Full income μ is then calculated using this wage rate measure as the value of leisure.

Our estimation does not include demographics, mainly for the reason of parsimony, but dynamics and habits could be affected by the use of demographics and may appear to be larger than they really are when heterogeneity between households is not taken into account. This will be true if and when habits are governed by demographics, e.g. number of children in the house, number of adults, number of females etc, or other measures of heterogeneity. One way that demographics could be included and preserve parsimony with a small sample is to estimate the dynamic demand system using predicted shares, where the effect of demographics is taken into account[23].

[23] This can be done with the nearest neighborhood estimator described by Estes and Honore (1995) and Yatchew (1997). For a detailed description see Lyssiotou et al. (1999).

4. EMPIRICAL SPECIFICATION AND ESTIMATION

The cost function used for the AI demand system, in its static form, with the addition of leisure, changes in the following, straightforward way[24]:

$$\log c(p, w, u) = (1 - u)\log[a(p, w)] + u \log[b(p, w)] \tag{23}$$

where

$$\log a(p, w) = \alpha_o + \sum_k^{n,l} \alpha_k \log p_k + 1/2 \sum_k^{n,l} \sum_j^{n,l} \gamma_{kj} \log p_k \log p_j \tag{24}$$

and

$$\log b(p, w) = \log a(p, w) + \beta_o \prod_k^{n,l} p_k^{\beta_k} \tag{25}$$

By applying Shephard's lemma we obtain the demand equations for goods and leisure in their budget forms:

$$w_i = \alpha_i + \sum_j^{n,l} \gamma_{ij} \log p_j + \beta_i \log(\mu/p) \quad \text{for goods i=1,...n} \tag{26}$$

$$w_m = \alpha_m + \sum_j^{n,l} \gamma_{ij} \log p_j + \beta_l \log(\mu/p) \quad \text{for male leisure} \tag{27}$$

$$w_f = \alpha_f + \sum_j^{n,l} \gamma_{ij} \log p_j + \beta_l \log(\mu/p) \quad \text{for female leisure} \tag{28}$$

---

[24] Notation $\sum_k^{n,l}$ and $\prod_k^{n,l}$ is used for simplicity, where n refers to prices of goods and services and l refers to wages.

where price index P is the price index as defined by

$$\ln P = \alpha_0 + \sum_{i}^{n,l} \alpha_i \ln p_{it} + 1/2 \sum_{i}^{n,l} \sum_{j}^{n,l} \gamma_{ij} \ln p_{it} \ln p_{jt} \tag{29}$$

The static case of (26) and (27) shows that nothing substantial changes in the model except from the use of μ, and everything is as it would be if leisure was just another commodity. Our sample consists only of married working couples. This gets around the problem of non-participation and hence zero wages and corner solutions for leisure. Wage is not exactly analogous to the price of commodities where the price exists whether the individual (or household) consumes the good or not. In our case, the synthetic panel technique we use no longer deals with the wage rates of individuals but with the average wage of a cohort, constructed from the average wage of the individuals belonging to a given cohort who are participating in the labour market and, thus, report a wage rate. This assumes that if an individual in a certain cohort is not participating, the opportunity cost of not doing so is the average wage rate of the cohort. Although it is implausible that there will be whole cohorts with zero wages or at a corner for leisure consumption, these households are excluded from the sample.

Introducing dynamics in this model faces no additional problems as we assume that leisure can be a habit forming good, but not a durable one, and so $d_{leisure} = 0$ and $0 \leq a_{leisure} < 1$. Habit formation for leisure is not an idea that is frequently met in the literature (see Kubin and Prinz (2002) and Vendrik (1993) for a further analysis of habit formation on labor supply). If work is habit forming then past work forms a stock of habits that increases current utility. It is an idea exactly analogous to habit formation for consumption which states that current utility is affected by current consumption relative to a "habit stock" determined by past consumption.

When considering habits we have to distinguish between three possible sources of persistence in behaviour: persistence if the environment the household faces (demographics, lifetime wealth, expectations etc), state dependence (either habits or durability) and heterogeneity. What we aim to identify here is state dependence that should not be affected by heterogeneity. It is well known that both state dependence and heterogeneity lead to persistence but for difference causes and their implications are very different. Consider, for example, smoking. The probability of smoking in the current period t is dependent on smoking behaviour in period $t-1$, but this could be because people are "smokers" (heterogeneity), or because something induced them to start smoking at some time and then continue (state dependence).

Even though one can argue that unobserved heterogeneity is averaged out in cohort data, there are ways to control the effects of unobserved heterogeneity at the individual level. This can be achieved by splitting the sample in sub-groups of interest, e.g. by age and education (i.e. young cohorts with low education, young cohorts with high education, and similarly for old cohorts). The only problem with this is that the resulting sub-samples may be too small for correct inference. Results should be addressed with caution. The estimation of the dynamic demand we formulate below is quite costly in itself, and the option of splitting the sample in sub-groups was not followed. However, the resulting estimation of the degree of habit persistence and durability is expected to be largely unbiased from unobserved heterogeneity, and we consider this one advantage of using cohort data.

Habit formation in labour supply may be explained in a similar fashion as habit persistence in consumption. The model tries to explain the hours of leisure chosen by married men and women. As far as women are concerned, one may expect that persistence in labour supply within cohorts comes through the effect of social conditions, just like for individuals. For example, older cohorts worked fewer hours than younger cohorts perhaps because lifestyles have changed, women were less educated, the financial pressures on a modern family are bigger than before, or because parental-leave was not available or child-care facilities were not as widely accessible and not sufficient to accommodate a full-time working mother. Indeed, other studies have found strong and significant habit persistence for the labour supply of married females (Woittiez and Kapteyn (1998)). Married men, on the other hand, should also exhibit strong habit persistence for labour supply as we would expect little variation in the average hours of work chosen each year by men in cohorts formed by married individuals.

The dynamic version of the empirical specification takes the form

$$p'_{it} z_{it} = (\alpha_i + \sum_j \gamma_{ij} \ln p'_{it} + \beta_i \ln(\mu'_t / P_t))\mu'_t \text{, for commodities, where } j=i,l \qquad (30)$$

$$w'_k l'_k = (\alpha_i + \sum_j \gamma_{ij} \ln p'_{it} + \beta_i \ln(\mu'_t / P_t))\mu'_t \text{, for leisure, where } k=m,f \qquad (31)$$

where

$$\ln P = \alpha_0 + \sum_i^{n,l} \alpha_i \ln p'_{it} + (1/2)\sum_i^{n,l} \sum_j^{n,l} \gamma_{ij} \ln p'_{it} \ln p'_{jt} \qquad (32)$$

and

$$\mu'_t = p'z + w'_m l_m + w'_f l_f \qquad (33)$$

The demand system will be estimated on the weights which are formed as follows for both commodities and male and female leisure:

$$w_{it} = \{p_{it}(a_i - d_i)S_{it-1} + (\alpha_i + \sum_j^{n,l} \gamma_{ij} \ln p'_{it} + \beta_i \ln(\mu_t / P_t))\mu'_t / p'_{it}\} / \mu_t \qquad (34)$$

Assuming that expectations of a price (or wage) follow a first order autoregressive process as was discussed in Section 2:

$$p_{it+1} = \xi_i + \rho_i p_{it} + \eta_{it} \qquad \text{for } i=1,\ldots,n \tag{35}$$

$$w_{mt+1} = \xi_m + \rho_m w_{mt} + \eta_{mt} \qquad \text{for male wage} \tag{36}$$

$$w_{ft+1} = \xi_f + \rho_f w_{ft} + \eta_{ft} \qquad \text{for female wage} \tag{37}$$

The above three equations (35), (36) and (37) are estimated along with the system of six equations implied by (34) and by substituting in equation (16), where the parametrization of p'_{it} is adopted for the parametrization of w'_{lt} as well. The estimation was carried out under the following restrictions:

(f) Adding-up: $\sum_i^{n,l} \alpha_i = 1$, $\sum_i^{n,l} \beta_i = 0$, $\sum_i^{n,l} \gamma_{ij} = 1$

(g) Homogeneity: $\sum_j^{n,l} \gamma_{ij} = 1$

(h) Symmetry: $\gamma_{ij} = \gamma_{ji}$

(i) Restrictions that ensure that $z's$ (effective quantities) are non negative:

$$\alpha_0 = \ln(\mu_{\min}),\ \alpha_i \geq 0,\ \alpha_i + \beta_i \ln(\mu_{\max} / \mu_{\min}) \geq 0$$

(j) Boundary restrictions that ensure that own price elasticities are negative:

$$\gamma_{ij} \leq (1 - w_{i,k})w_{i,k} - \alpha_0 \beta_i^2$$

The system of equations was estimated under several specifications concerning the a's and d's. Here it is useful to note that although they are separate, both parameters can capture durability and habit persistence to some degree. In order to make this more clear consider that if we let $d_i = 0$ then $z_{it} = q_{it} - a_i q_{it-1}$, so z_{it} is essentially a stock when $a_i < 0$. So, if one estimates the system restricting $d_i = 0$ and lets a_i free, then a negative coefficient on the a_i of a good other than durables would indicate that the model is picking up durability of some degree, instead of habituation. The opposite would be true if the specification estimated restricting the $\alpha's$ to be zero and let $d's$ free, then a positive d would pick up habituation.

The specification chosen to be presented was estimated under the restriction that $d_i = 0$ except for durables and $a_i > 0$[25]. The choice to restrict all $d's$ to be zero except for durables can be justified exactly by the fact that, to some extend, both parameters, *a* and *d*, can capture durability and habits. So, including only one of them for goods that we can safely assume a priori are not really durable does not cost us in terms of interpretation of results. The other reason for choosing to restrict *d's* is parsimony, which is important with the sample size we have available here. The parameter estimates and the diagnostics associated with them are presented in Table 4.1.[26]

The results on habit persistence show strong habit persistence and durability effects for durables. Non durables also show considerable habit persistence, in contrast to miscellaneous goods and services and energy and transport. Habit coefficients for the two latter commodity groups are indeed very low. Female leisure shows a substantial degree of habit persistence in contrast to male leisure. The results on male leisure are not as expected, and this could be attributed to the fact that we do not split the cohorts into education groups since education is a dominant source of the variation in average

[25] This gave quite satisfactory results and was then used to explore non-zero values of d_i for the rest of the commodity groups. None of these were found to be significant so the specification presented in Table 4.1 was accepted as the most parsimonious dynamic specification of the AI demand system.
[26] The estimations rely on the fact that the real rate of interest was assumed to be .02 throughout as is commonly done in demand analysis.

cohort wage. Generally, the results are characterized by the strong results on durables and this can in part be accounted on the use of average cohort data.

Separability test

Separability of commodity demands and leisure can be easily tested in the context of the dynamic AI demand system used here by conducting Wald type test on the hypothesis that commodity demands are separable from leisure, and also on the hypothesis that male leisure and female leisure respectively are separable from commodity demands. This test constitutes of joint tests on the parameters of the price index as follows. In order to test separability, one has to test whether the γ`s in all share equations relating to male and female wage are zero. The hypothesis to test is thus:

$$H_0: \gamma_{15} = \gamma_{16} = \gamma_{25} = \gamma_{26} = \gamma_{35} = \gamma_{36} = \gamma_{45} = \gamma_{46} = 0$$

The Wald test is reported in Table 4.1, and it indicates a rejection of the separability hypothesis, i.e. it rejects separability of commodity demands from leisure, and due to symmetry it also indicates that leisure is non-separable from commodity demands and $d_i = 0$ for durables. They show that the data strongly reject the hypotheses, and thus addictive and durability effects are important determinants of demand.

Table 4.1: Estimates of the dynamic AI demand system

	Non-durables	Misc-ellaneous	Fuel, light and transport	Durables	Male leisure	Female leisure
α_i	0.349	0.006	0.140	0.001	0.237	0.266
	(0.034)	(0.026)	(0.017)	(0.017)	(0.011)	(0.015)
β_i	-0.008	0.106	0.002	0.039	-0.075	-0.066
	(0.019)	(0.016)	(0.012)	(0.009)	(0.006)	(0.009)
γ_{i1}	-0.290	-	-	-	-	-
	(0.066)					
γ_{i2}	0.104	0.103	-	-	-	-
	(0.044)	(0.042)				
γ_{i3}	-0.017	-0.001	0.017	-	-	-
	(0.006)	(0.005)	(0.003)			
γ_{i4}	0.147	-0.119	0.008	0.024	-	-
	(0.025)	(0.020)	(0.003)	(0.016)		
γ_{i5}	0.030	-0.038	-0.005	-0.033	0.066	-
	(0.018)	(0.014)	(0.003)	(0.009)	(0.004)	
γ_{i6}	0.026	-0.049	-0.002	-0.027	-0.020	0.071
	(0.021)	(0.017)	(0.003)	(0.010)	(0.009)	(0.005)
a_i	0.283	0.065	0.053	0.820	0.096	0.261
	(0.041)	(0.047)	(0.022)	(0.115)	(0.083)	(0.047)
d_i	-	-	-	0.852	-	-
				(0.096)		
R-square	0.7535	0.5631	0.2651	0.3150	0.6688	0.7493
Adj R-square	0.7433	0.5448	0.2344	0.2864	0.6537	0.7379
Root MSE	0.0186	0.0192	0.0191	0.0160	0.0108	0.0140
Separability	$\chi^2 = 92.23$ (P-value=0.0000)					
Habit effects	$\chi^2 = 212.4$ (P-value=0.0000)					
Durability effects	$\chi^2 = 79.43$ (P-value=0.0000)					
Symmetry	Restricted 532.98 (40)		Unrestricted 489.33 (55)	(Critical value= 26.27)		
Homogeneity	-244.40 p-value= 0.0128	-5.55 p-value= 0.9205	1045.29 p-value= 0.0060	499.09 p-value= 0.0000	16.59 p-value= 0.8868	-208.63 p-value= 0.1249

Symmetry is rejected[27] which is in contrast to other empirical evidence on the dynamic demand systems (Muellbauer and Pashardes (1992), Anderson and Blundell (1986)). Homogeneity, however, cannot be rejected by four of the share equations (non-durables, miscellaneous, male leisure and female leisure). Also, Wald tests on the significance of the habits and durability parameters are provided, testing the hypothesis that $a_i = 0 \quad all\ i$ for habits

Elasticities

The price elasticities are reported in Table 4.2 and correspond to the instant uncompensated price elasticities. All own price elasticities are negative, and point to the direction that would be expected. Muellbauer and Pashardes (1992) who used aggregate data failed to find a negative own price elasticity of food. A negative cross price elasticity indicates that the goods are complements, whereas a positive one indicates that they are substitutes. The results yield some quite interesting conclusions.

Non-durables and male leisure appear to be substitutes as the positive cross price elasticity indicates (0.095 and 0.360). The same applied for non-durables and female leisure. Both male and female leisure are complements with miscellaneous goods and services (-0.168, -0.214) which is not a surprising result considering the commodities included in this group (e.g. clothing and footwear). Energy and transport is a complement to male and

[27] This test is based on imposing the covariance of the unrestricted model to the restricted estimates and the difference of the log-likelihood function between the unrestricted and the restricted estimates is computed.

female leisure. As the price of leisure increases (the wage), consumption on energy and transport decreases and this could especially apply to the energy consumed by a household of a working couple. Durables are supplements to female and male leisure. Finally, male leisure seems to be a complement to female leisure and vise-versa.

Table 4.2: Instant own and cross price elasticities

	Non-durables	Misc-ellaneous	Energy and transport	Durables	Male leisure	Female leisure
Non-durables	-1.564	0.314	-0.042	0.442	0.095	0.085
	(0.203)	(0.129)	(0.025)	(0.077)	(0.064)	(0.070)
Miscellaneous	0.446	-0.492	-0.006	-0.520	-0.168	-0.214
	(0.196)	(0.187)	(0.022)	(0.089)	(0.060)	(0.069)
Energy and transport	-0.120	-0.007	-0.829	0.051	-0.038	-0.018
	(0.042)	(0.039)	(0.030)	(0.024)	(0.016)	(0.023)
Durables	1.691	-1.372	0.088	-0.937	-0.379	-0.310
	(0.297)	(0.275)	(0.031)	(0.181)	(0.098)	(0.109)
Male leisure	0.360	-0.154	0.095	-0.116	-0.267	-0.016
	(0.149)	(0.112)	(0.030)	(0.069)	(0.030)	(0.071)
Female leisure	0.201	-0.144	0.071	-0.043	-0.011	-0.329
	(0.106)	(0.079)	(0.025)	(0.048)	(0.046)	(0.023)

As Table 3 shows, the commodity groups are necessities and luxuries as expected. Namely, from the commodity groups, only non-durables are necessities, with a budget elasticity of -0.7. Miscellaneous goods and services appear as luxuries with budget elasticity a bit above unity and the same applies for the fuel, light and transport group.

Durables have the highest budget own price and budget elasticities. Male and female leisure appear as necessities, meaning that as income, and in this case full income, increases expenditure on leisure increases by less than the percentage increase in full income. Intuitively, this would be more expected for female leisure, and less expected for male leisure. The own-price female leisure elasticity captures the forward sloping female labour supply. The negative result of the own-price elasticity for male leisure, however, relies on the fact that boundary conditions were imposed on the estimation to ensure negative own-price elasticities.

Table 3: Budget elasticities

Non-durables	0.694 (0.063)
Semi-durables	1.396 (0.093)
Fuel, light and transport	0.963 (0.078)
Durables	1.595 (0.101)
Male leisure	0.338 (0.046)
Female leisure	0.436 (0.050)

5. CONCLUSIONS

This paper has estimated a dynamic demand system of commodity demands and leisure using synthetic cohort data created from a sample of the UK Family Expenditure Survey covering the period 1987-2001. The sample was restricted to married couples with or without children. A further restriction consists of restricting the sample for males and females above statutory retirement age. This method allows testing of durability and habit persistence in both commodity demands and leisure. The model used is a modified version of the dynamic demand system developed by Muellbauer and Pashardes (1992), based on the Almost Ideal demand system. Dynamics in the system are introduced through durability and habit formation by substituting quantities with effective quantities which form a linear transformation of actual quantities. Durability and habit persistence are expressed by two different parameters which allow us to distinguish empirically between the two. However, one can include either of the two parameters in the model, in which case the sign of the parameter indicates durability and habit persistence, as in many other studies of these issues (Spinnewyn (1981), Pashardes (1986)). The modification consists of including leisure in the model and introducing price expectations that are not constant.

The model is estimated for four commodity groups, namely non-durables (food and alcohol), miscellaneous goods and services (clothing and footwear, household goods and services, leisure goods and services etc), energy and transport and durables (vehicles, electrical goods, furniture and furnishings). Along with the four commodity groups, two more share equations are estimated, one for male leisure and another for female leisure.

The results indicate that consumption shows considerable habit persistence for food, alcohol and tobacco and durables. The results on durables are quite strong both for the habit and durability estimates. Female leisure exhibits considerable habit persistence, in contrast to male leisure.

The model allows for the estimation of own-price and budget elasticities for both commodities and leisure. The own-price and budget elasticities for the commodities have the expected signs. The wage elasticity of male leisure is negative, indicating that the model captures males on the forward sloping part of the backward bending male labour supply. The results on the wage elasticity of female leisure capture the forward sloping female labour supply. Cross-price elasticities are also estimated and the results are quite interesting and informative.

Overall the results obtained from the analysis is in line with past evidence on habit persistence. This indicates that the dynamic demand framework used, including leisure as an unconditional variable in the model is a useful instrument for empirical investigation of labour supply issues, including indirect taxation issues. Some interesting, but quite complicating, extensions would be exploring consumption decisions nearing retirement age and reactions of labour supply to changes in taxation and benefits regimes. This framework would demand a true panel dataset that would better capture the effects, and also provide with a large number of observations needed for the computationally costly extensions.

REFERENCES

Alessie R, Kapteyn A (1991), "Habit formation, interdependent preferences and demographic effects in the almost ideal demand system", *Economic Journal*, 101, pp404-419

Anderson G, Blundell R (1982), "Estimation and hypothesis testing in dynamic singular equations systems", *Econometrica*, 50, 1559-1571

Bernstein J, Mamuneas T.P., Pashardes P. (1999), "Factor Adjustment, Quality Change and Productivity Growth for U.S. Manufacturing", NBER Working Paper 6877

Blundell R, Walker I (1982), "Modelling the Joint Determination of Household Labour Supplies and Commodity Demands", *Economic Journal*, 92, 351-364

Bover O (1991), "Relaxing Intertemporal Separability: A Rational Habits Model of Labour Supply Estimated from Panel data", *Journal of Labour Economics*, 9, 85-100

Browning M (1991), "A simple non-additive preference structure for models of household behavior over time", *Journal of Political Economy*, 99, 607-637

Browning M, Meghir C (1991), "The Effects of Male and Female Labour Supply on Commodity Demands", *Econometrica*, 59, 925-951

Carasco R., Labeaga J.M., Lopez-Salido J.D., (2005), "Consumption and Habits: Evidence from Panel Data", *The Economic Journal*, 115, 144-165.

Constantinides G.M. (1990), "Habit Formation: A Resolution of the Equity Premium Puzzle", *Journal of Political Economy*, 98, 519-543

Deaton A, Muellbauer J (1980), "An Almost Ideal Demand System", *American Economic Review*, 70, 312-326

Deaton A, Muellbauer J (1980), *Economics and Consumer Behavior*, Cambridge: Cambridge University Press

Dynan K (2000), "Habit Formation in Consumer Preferences", *American Economic Review*, 90, 391-406

Estes E., Honore B. (1995), "Partially Linear Regression using one Nearest Neighbor", Princeton University, Department of Economics, manuscript

Gorman W (1967), "Tastes, Habits and Choices", *International Economic Review*, 8, 218-222

Hayashi F (1985), "The Permanent Income Hypothesis and Consumption Durability: Analysis Based on Japanese Panel Data", *Quarterly Journal of Economics*, C, 1083-1113

Houthakker H.S., Taylor L (1966, 1970 2nd ed.), *Consumer Demand in the United States 1929-70, Analysis and Projections*, Cambridge, Mass.; Harvard University Press

Kubin I, Prinz A (2002), "Labour supply with habit formation" *Economics Letters*, 75, 75-79

Lluch C. (1974), "Expenditure , savings and habit formation", *International Economic Review*, 15, 768-797

Lyssiotou P., Pashardes P., Stengos T. (1999), "Testing the rank of Engel curves with endogenous expenditure", *Economics Letters*, 64, 61-65.

Meghir C, Weber G (1996), "Intertemporal Non-Separability or Borrowing Restrictions? A Disaggregate Analysis Using a U.S. Consumption Panel", *Econometrica*, 64, 1151-82

Muellbauer J, Pashardes P (1982, 1992), "Tests of dynamic specification and homogeneity in a demand system", Birkbeck College Discussion Paper No. 125; revision published in Phlips L and Taylor LD (ed.) *Aggregation, Consumption and Trade: Essays in Honour of Hendrick Houthakker*, Kluwer Academic Publishers, 55-98.

Naik N.Y., Moore M.J. (1996), "Habit Formation and Intertemporal Substitution in Individual Food Consumption", *The Review of Economics and Statistics*, 78, 321-328

Pashardes P (1986), "Myopic and forward looking behaviour in a dynamic demand system", *International Economic Review*, 27, 387-398

Phlips L (1972), " A dynamic version of the linear expenditure model", *Review of Economics and Statistics*, 54, 450-458

Phlips L (1974), Applied consumption analysis (North-Holland, Amsterdam)

Phlips L, Spinnewyn F (1982), "Rationality versus myopia in dynamic demand systems", *Advances in Econometrics*, 1, 3-33, JAI Press

Pollak R. A. (1969), " Conditional Demand Functions and Consumption Theory", *Quarterly Journal of Economics*, 83, 70-78

Pollak R. A. (1970), "Habit formation and dynamic demand functions", *Journal of Political economy*, 78, 745-753

Pollak R. A. (1971)," Conditional Demand Functions and Consumption Theory", *Southern Economic Journal*, 37, 423-433

Pollak R. A. (1976), "Habit formation and long run utility functions", *Journal of Political Economy*, 13, 292-297

Pollak R. A. (1978),"Endogenous tastes in demand and welfare analysis", *American Economic Review*, 78, 374-379

Pollak R. A., Wales R. (1969), "Estimation of the linear expenditure system", *Econometrica*, 3, 1-48

Spinnewyn F (1979), "The cost of consumption and wealth in a model of habit formation", *Economic Letters*, 2, 145-148

Spinnewyn F (1981), "Rational Habit formation", *European Economic Review*, 15, 91-109

Stoker T (1986), "Simple tests of distributional effects on macroeconomic equations", *Journal of Political Economy*, 94, 763-95

Taylor L, Weiserbs D (1972), "On the estimation of dynamic demand functions", *Review of Economics and Statistics*, 54, 459-465

Vendrik, M.C.M (1993), "Habits, hysterisis and catastrophes in labour supply", *Journal of Economic Behaviour and Organization*, 20, 353-372

Weissenberger E (1986), "An intertemporal system of dynamic consumer demand functions", *European Economic Review*, 30, 859-891

Woittiez I, Kapteyn A, (1998), "Social Interactions and habit formation in a model of female labour supply", *Journal of Public economics*, 70, 185-205

Yatchew A.J. (1997), " An elementary estimator of the partial linear model", *Economics Letters*, 57, 135-143

APPENDIX: The parameter estimates of the AR(1) price equations

The parameter estimates are presented in the table below.

	Non-durables	Miscellaneous	Energy and Transport	Durables	Male leisure	Female Leisure
ξ_i	0.069	0.157	0.243	0.314	0.144	0.124
	(.007)	(.023)	(.056)	(.051)	(.029)	(.039)
ρ_i	0.964	0.856	0.800	0.676	0.889	0.923
	(.008)	(.025)	(.067)	(.054)	(.032)	(.041)
R- Square	0.9933	0.9259	0.5983	0.6183	0.8900	0.8384
Adj R-Sq	0.9932	0.9251	0.5942	0.6143	0.8889	0.8367
Root MSE	0.0120	0.0261	0.2857	0.0394	0.0632	0.0896